

Bird Strike Committee Canada

Meeting 27, November 25 & 26, 1997

CO-CHAIRS:

Capt. Sara Karcha, Department of National Defence and Bruce MacKinnon,
Transport Canada.

MINUTES PREPARED BY:

My Luong, Mark Rogers, and Phillip Scott, Transport Canada

NEXT MEETING:

Tentatively planned for May, 1998 in Thunder Bay.

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Minutes of the 27th meeting of Bird Strike Committee Canada

November 25 and 26, 1997
Delta Hotel
Ottawa, Ontario, Canada

Day 1

1.0 Introduction and Welcome

Bruce MacKinnon, Wildlife Control Specialist, Transport Canada, opened the meeting by welcoming all attendees. He introduced Capt. S. Karcha from DND, who recently replaced Capt. Mario Larose as co-chair. He then introduced the co-op students, My Luong and Mark Rogers, and finally, the Director of Aerodrome Safety Branch, Harvey Layden.

Harvey Layden gave the official welcome with an update on what Transport Canada is currently involved in and its future focus in terms of Wildlife Control at Aerodromes. He provided an update on the Canadian Aviation Regulations, Part 3, and the CARAC process.

2.0 Introduction of Attendees

Introductions were made around the table.

3.0 Keynote Address

Captain Paul Eschenfelder described his involvement as co-chair of the ALPA-ACI Bird Hazard Working Group. He also discussed the need for more active involvement by industry stakeholders in order to mitigate wildlife problems at airports.

4.0 1997 Bird Strike Statistics

4.1 Department of National Defence (DND)

Capt. S. Karcha presented the latest bird strike data for DND. In September of this year, a Tutor crashed, in Saskatchewan. It has been confirmed that a bird strike caused the crash. Fortunately, the two pilots in the aircraft ejected safely at 1000ft AGL. For the 1996 Canadian Forces bird strike data, please see appendix 3.

4.2 United States Air Force (USAF)

Leah Fry presented the USAF Strike statistics. She informed the attendees that in 1997, there have been 2300 reported bird strikes causing \$8 Million in damage. The Horned Lark was the species struck most often and the KC-135R was the aircraft involved in the most birds strikes (please see appendix 4).

4.3 Transport Canada

Bruce MacKinnon presented the strike statistics for Transport Canada. Bruce pointed out that as of Nov.15, there have been 533 bird strikes reported to Transport Canada. The predominant species are gulls, sparrows, swallows, and hawks. He also discussed some significant strikes that occurred in 1997. One particular incident happened on August 18 when a McDonnell-Douglas DC9 struck some birds on takeoff in Thunder Bay, causing the left engine to wind down. The engine was re-lit using the igniter override, however, the engine vibrations were beyond limits so the crew shut down the left engine and returned for a landing with ERS standing by (please see appendix 5).

4.4 International Civil Aviation Organization (ICAO)

Alistair Pinos discussed the method of reporting strikes in ICAO. He noted that because there are inconsistencies in reporting wildlife strikes, the United States has decided to use a statistical analysis method and apply it to the significant strikes. As a result, the United States would generate a State Letter using this analysis.

5.0 Updates-TDC Project & Efficacy Study: Wildlife Control Equipment and Techniques

Dr. Rolph Davis provided an update on the TDC project. He explained that it was very difficult to determine the cost of bird strike damage by consulting with the airlines because they do not record this type of information. He noted that it was also difficult to calculate the indirect cost of damage caused by wildlife strikes. Therefore, generic costs were used because this information is available. The results of this project should be available at BSCC 28.

Dr. Davis then discussed the Efficacy Study. He informed the attendees that there are numerous types of bird control techniques available, some old and some new. In order to select a good technique, there are a series of questions one must ask. The following are the steps or questions that should be asked:

- 1) Operational Analysis: Where is it used, how is it used?
- 2) Biological/Behavioural Basis for the equipment: Are the techniques useful, Is there a basis for the techniques?
- 3) Skill/Knowledge of Operator: Is the operator adequately skilled to properly use the technique?
- 4) Creation of New Problems: Some techniques cause problems, therefore we must look at the situation case by case, i.e., one technique may work for one case and not for another.
- 5) Evidence: Are there any objective data available, was habituation considered, do the techniques depend on available habitat nearby, were special circumstances present, is there operational experience on airports?
- 6) Conclusions: After the questions are asked, conclusions can then be drawn, such as: is the technique useful, is the technique helpful as part of an integrated program, is the technique not useful, and finally, is the technique potentially useful after analyzing the objective data?

6.0 FAA Wildlife Strike Database

Sandra Wright noted that bird strike data has been collected since 1965 by the FAA, but it was not until 1995 that they started to analyze the data. She provided a presentation on "Coyotes on

Airports: Safety Hazard or Unpaid Member of the Bird Strike Team?" For more information on this, please refer to appendix 9.

7.0 ATM Bird Hazard Awareness Video (Plane Jeopardy)

Tim Joyce from Sound Venture Productions and *Bruce MacKinnon* presented the off-line version of "Plane Jeopardy", a training and awareness video for air traffic management staff.

Comments were provided by BSCC participants.

8.0 FAA Wildlife Strike Database

Sandra Wright presented, "Evaluation of shotgun shooting to reduce aircraft strikes by Gulls at J.F.K. International Airport 1991-1997". For more information on this, please refer to appendix 10.

Also, Sandra discussed another study: "Do Canada Geese Prefer Tall or Short Grass?". Please refer to appendix 11.

9.0 Software Tool To Comply with Proposed Transport Canada Standards and Regulations Related to Wildlife Control

John Phyper spoke about software tools to assist Canadian Aerodromes to comply with proposed legislation. Three items were discussed:

- 1) Wildlife Data Management Tool
- 2) Auditing Tool
- 3) Interactive Training System.

For a detailed description of these items, please see appendix 13.

10.0 Update-Wildlife Control Program: Calgary International Airport

Terry Thompson updated the attendees with some highlights of the Wildlife Control Program at Calgary International Airport:

- *Inventory and Habitat Evaluation:* This included a bird Monitoring Program Summary. The monitoring program took two years to complete.
- *Areas of Concern:* These areas include the north stormwater retention pond, the farm north of the airport with abandoned buildings and open grain piles, and the goose Lagoon which caused an increase in waterfowl numbers on the site.
- *Hazard Evaluation and Control:* Bird strike data is collected (numbers and species), bird strike analysis is done (time of day and phase of flight), recommendations on control efforts are generated.
- *Habitat Modification:* This involves environmental assessment of the projects and looking at possible modification to decrease bird hazards. Waste construction material is used to fill low areas that collect water. For the north retention pond, there is an operational plan for reducing nesting habitat when water levels are altered.

- *Recommendations:* Live trapping of raptors (this was tried with little success last year, but new trap designs should help), removal of hay bales to reduce perching opportunities, test the use of repellents (avitrol for starlings, and methyl anthranilate for waterfowl).
- Work more closely with farmers north of the site, and operators of the golf course located south of the site.

11.0 Update-Wildlife Control Program: Vancouver International Airport

Dave Ball updated the attendees on the wildlife control program at Vancouver International Airport. He noted that the data being analyzed for the program was collected during the past four years. Considerable work is being done on grass management issues. (please see appendix 12)

12.0 Update-Transport Canada Wildlife Control Training Program

Dave Fairbairn described the courses held in Halifax and Calgary this year. The courses have been modified to be more useful to Transport Canada Aerodrome Inspectors. The next course will be on March 24/25, 1998 in Toronto.

13.0 An Innovative Approach to Bird Strike Prevention At National Defence

Please see *Rob Cretain's* paper in appendix 14.

14.0 An Evaluation of Anthraquinone As an Avian Feeding Repellent

Dr. Melvin L. Kreithen discussed the Quinones and Anthraquinones. He stated that birds will not approach any edible foods with these ingredients in them. The colour of this ingredient is not visible to the human eye, but birds can see it very well.

15.0 Bird Flight Forecast Modeling

Harlan Shunnon began his presentation by describing boundary layers surrounding the earth and their importance in terms of bird movement. He then described the "Bird Flight Forecast Model".

Day 2

16.0 Constructed Wetlands for Remediation of Ethylene Glycol at Airports

Please see Appendix 15 for information on *Dr. James Higgins'* presentation.

17.0 Other Business - Conclusion

The next BSCC meeting will be held in Thunder Bay, Ontario, on June 9-10, 1998. Also, there will be a Bird Strike Committee USA meeting June 16-18, 1998 at Burke Lakefront Airport, Cleveland Ohio (please see appendix 16 for further information).

18.0 National Aviation Museum

Following completion of the presentations, participants were provided the opportunity to visit the National Aviation Museum and the Flight Impact Simulator Facility at MacDonald Cartier International Airport.

19.0 Flight Impact Simulator Facility

This Facility is located at the National Research Council of Canada, Uplands Airport Campus, Ottawa. Bosik Consultants Limited is the company that runs this facility. *Todd A. Bosik* provided a tour of the Facility and described the different High G impact testing and ballistics testing programs the company conducts. For further information on this, please see appendix 17 and 18.

BIRD STRIKE COMMITTEE CANADA
MEETING 27, November 25 & 26, 1997

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2. BSCC 27 Agenda
3. 1996 Bird Strike Statistics: Canadian Forces
4. 1997 Bird Strike Statistics: USAF BASH Team
5. 1997 Bird Strike Statistics: Transport Canada
6. ICAO Journal, 25(7), Sept. 1997: Bird strike analysis uses world data
7. 1996-97 FAA Significant Strikes
8. FAA Report: Wildlife Strikes to Civil Aircraft in the U.S. 1992-1996
9. Coyotes on Airports: Safety Hazard or Unpaid Member of the Bird Strike Team?
10. Shooting Gulls to Reduce Strikes with Aircraft at J.F.K. International Airport (1991-1997)
11. Do Canada Geese Prefer Tall or Short Grass?
12. The Wildlife Control Program at the Vancouver International Airport
13. Wildlife Management Software Tools
14. Innovations to Support Wildlife Management Planning at Airports
15. Soil Enrichment Systems Inc.
16. Bird Strike Committee USA - meetings, information
17. Bosik Consultants Ltd.
18. Capabilities of the NRCC/NAE Flight Impact Simulator Facility
19. North American Bird Hazard Reduction Efforts Since the 707 AWACS Accident at Elmendorf, AFB
20. Using the Internet to Support Aviation Safety Research and Education
21. ARFF Hot News
22. New tipping fees at the Robin Hood Bay dump to increase 92 percent
23. Who Rules the Skies?
24. FAAviationews, Nov./Dec. 1996: Watch out for Rudolph! He may be trespassing on your airport
25. Morning Smile
26. Winnipeg Airports Authority: Bird Control Advisory Committee Update
27. Assessment of Browning-Ferris Industries (BFI) Gull Control Program at The Rosser Integrated Waste Management Facility
28. Wildlife Management at YVR & Environs - Report of a System Safety Review, July 23-24, 1997
29. Caribou and Aircraft Overflights
30. Stowaway Starling
31. Airport Land Uses Require Planning to Prevent Wildlife-Aircraft Strikes

32. The Potential for financial loss resulting from aircraft bird strikes
33. The Brazilian Bird Strike Reduction Program
34. Stephenville Airport Bird Survey, 1997
35. Bird Strikes! - FOCUS, August 1997
36. The Globe and Mail, Thursday, November 6, 1997: How lake birds are making a comeback
37. Aerodrome Safety Information Circular, December 19, 1997
38. FAAviationews: Nov./Dec. 1997: Canada Geese: Flying Elephants We Must Avoid!
39. Numbers, movements and behaviour of gulls using the Robin Hood Bay Waste Disposal Site: Relationship to aircraft safety at the St. John's Airport, Newfoundland
40. The Globe and Mail, Friday, January 2, 1998: Think owls are bad?
41. Plane and Pilot, February 1998: Bird Strike

APPENDIX 1

Organizational Letter



Transport
Canada

Transports
Canada

Safety and Security Sécurité et sûreté

Aerodrome Safety Branch
330 Sparks St., Place de Ville, Tower C
Ottawa, Ontario
K1A 0N8

Your file Votre référence

Our file Notre référence

August 25, 1997

AKP 5158-36-20-51

Members/Participants
Bird Strike Committee Canada

Dear Member/Participant:

I am pleased to advise you that the Bird Strike Committee Canada meeting #27 will be held in Ottawa on Tuesday and Wednesday, November 25 and 26, 1997. The meeting will be held in the Victoria Room:

Delta Ottawa Hotel
361 Queen Street
Ottawa, Ontario
K1R 7S9

There is a block of rooms reserved at the hotel under 'Bird Strike Committee Canada' at a rate of \$125.00 per night, single or double occupancy. The price does not include taxes. Reservations can be made by calling toll free: 1-800-268-1133 or direct: (613) 238-6000. We recommend that you book your room as soon as possible.

We are in the process of establishing the agenda, so if you have agenda items or would like to present a paper, please contact me before September 30, 1997.

We look forward to seeing you in Ottawa, and if you have comments or questions, please feel free to contact me at (613) 990-0515 or by fax (613) 990-0508.

Regards,

Bruce MacKinnon
Wildlife Control Specialist

Canada

APPENDIX 2

BSCC 27 Agenda

AGENDA TIMETABLE

BIRD STRIKE COMMITTEE CANADA 27TH MEETING

OTTAWA, ONTARIO
NOVEMBER, 1997

Tuesday, November 25, 1997

TIME	SUBJECT	SPONSOR
0830-0900	COFFEE AND MUFFINS	ALL
0900-0905	WELCOME	BRUCE MACKINNON CAPTAIN S. KARCIA
0905-0915	OPENING	HARVEY LAYDEN DIRECTOR-AERODROME SAFETY BRANCH
0915-0945	KEYNOTE ADDRESS	CAPTAIN PAUL ESCHENFELDER ALPA
0945-1000	1997 BIRD STRIKE STATISTICS	DND, USAF, TC, AC, CAL, FAA, ICAO
1000-1030	COFFEE	ALL
1030-1050	UPDATES -TDC PROJECT -EFFICACY STUDY-WILDLIFE CONTROL EQUIPMENT AND TECHNIQUES	DR. ROLPH DAVIS
1050-1105	FAA WILDLIFE STRIKE DATABASE	SANDRA WRIGHT
1105-1130	GULL MANAGEMENT PROGRAM -JFK INTERNATIONAL AIRPORT	DR. RICHARD DOLBEER
1130-1200	ATM BIRD HAZARD AWARENESS VIDEO (PLANE JEOPARDY)	TIM JOYCE BRUCE MACKINNON
1200-1300	LUNCH	ALL
1300-1315	UPDATE-WILDLIFE CONTROL PROGRAM -CALGARY INTERNATIONAL AIRPORT	TERRY THOMPSON
1315-1330	UPDATE-WILDLIFE CONTROL PROGRAM -VANCOUVER INTERNATIONAL AIRPORT	DAVE BALL
1330-1340	UPDATE-BIRD HAZARD HANDBOOK	BRUCE MACKINNON
1340-1345	UPDATE-TC WILDLIFE CONTROL TRAINING PROGRAM	DAVE FAIRBAIRN
1345-1400	SOFTWARE TOOL TO COMPLY WITH PROPOSED TRANSPORT CANADA STANDARDS AND REGULATIONS RELATED TO WILDLIFE CONTROL	JOHN PHYPER
1400-1430	LEGACIES-THERE IS A CHOICE	USAF VIDEO
1430-1435	UPDATE-GULL CONTROL ADVISORY COMMITTEE -WINNIPEG INTERNATIONAL AIRPORT	BRUCE MACKINNON
1435-1500	COFFEE	ALL

TIME	SUBJECT	SPONSOR
1500-1520	AN EVALUATION OF ANTHRAQUENONE AS AN AVIAN FEEDING REPELLENT	DR. MELVIN L. KREITHEN
1520-1540	AN INNOVATIVE APPROACH TO BIRD STRIKE PREVENTION AT NATIONAL DEFENCE	ROB CRETAIN
1540-1600	BIRD FLIGHT FORECAST MODELING	JARLAN SHANNON

DAY 2

Wednesday, November 26, 1997

TIME	SUBJECT	SPONSOR
0830-0900	COFFEE AND MUFFINS	ALL
0900-0920	CONSTRUCTED WETLANDS FOR REMEDIATION OF ETHYLENE GLYCOL AT AIRPORTS	DR. JAMES HIGGINS
0920-0930	DISCUSSION: REGULATIONS, STANDARDS, RECOMMENDED PRACTICES-WILDLIFE CONTROL AT AERODROMES	BRUCE MACKINNON
0930-1000	OTHER BUSINESS -CONCLUSION	ALL
1000	BUS DEPARTS DELTA OTTAWA FOR NATIONAL AVIATION MUSEUM	
1030-1200	FIELD TRIP -NATIONAL AVIATION MUSEUM	ALL
1200-1330	LUNCH	ALL
1330	BUS DEPARTS NATIONAL AVIATION MUSEUM FOR MACDONALD CARTER INTERNATIONAL AIRPORT	
1400-1530	FIELD TRIP -FLIGHT IMPACT SIMULATOR FACILITY(BIRD GUN)	BOSIK CONSULTANTS LTD.
1530-1600	BUS RETURNS TO DELTA OTTAWA HOTEL	

APPENDIX 3

1996 Bird Strike Statistics: Canadian Forces

****CADORS**** National Report dated (nv/j/a) 9/29/1997 with 34 record(s).

Cadors No.: 97C0671 Registration: C-
Other Identification: Reported By: RCMP
Date: 1997/09/25 Time: 2300 TimeZone: Z
Location: 8 SW of Assiniboia, SK

Occurrence: Accident Fatalities: 0 Phase of Flight: Cruise
First Event: 252 Bird Strike
Second Event: 203 Engine Failure

Aircraft: CANADAIR CT-114 Tutor
Aircraft Category: Acroplane Gear: Land Year Built:
Engine Type: Turbo jet
Engine Manufacturer: UNKNOWN
Aircraft Owner: DEPARTMENT OF NATIONAL DEFENCE
Aircraft Operator:
Record Last Updated By: Rod Ridley

*****Details*****

The CT-114 Tutor a/c was on a dual training flight out of Moose Jaw, when the a/c encountered a flock of unidentified birds southwest of Assiniboia. The pilots attempted to maneuver away from the birds, but apparently one of them was ingested into the air intake, causing the engine to flame out. The two pilots ejected and came down in a farmer's field, with the student pilot suffering a severely sprained back in the process. He was taken by ambulance to the hospital in Assiniboia and was subsequently transferred to the base hospital at Moose Jaw. The a/c went down adjacent to a road, and in a field, causing no damage to anything on the ground. It was reported that the military was in the process of removing the a/c, and returning it to Moose Jaw as well. The canopy, seats and parachutes were also picked up north of where the a/c was found.

The area is a well-known migration route for geese and ducks. There are numerous stubble fields and sloughs in the vicinity, which provide feeding and resting places for the birds on their yearly migration south.

1996 Bird Strikes Statistics

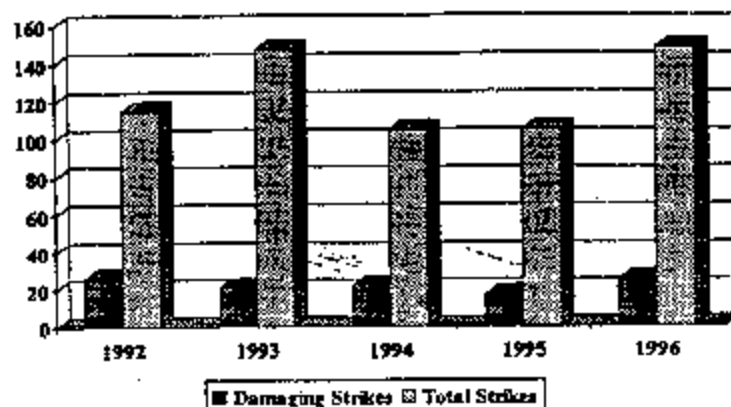
Canadian Forces



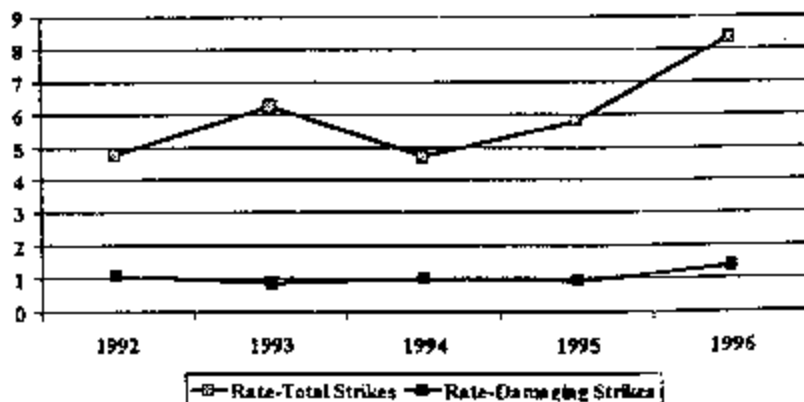
Captain Mario Larose



Bird Strikes Canadian Forces



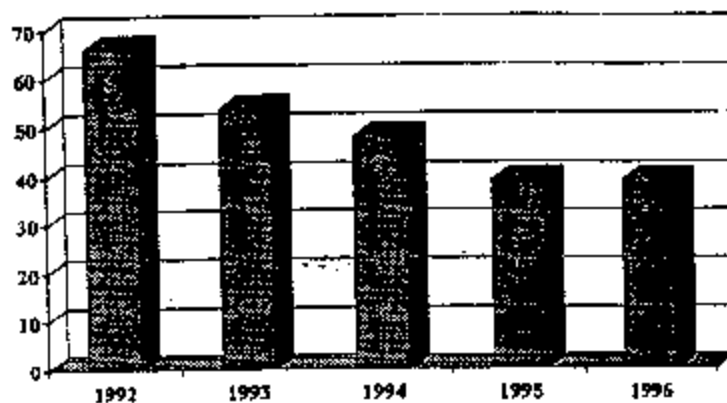
Bird Strike Rates Canadian Forces



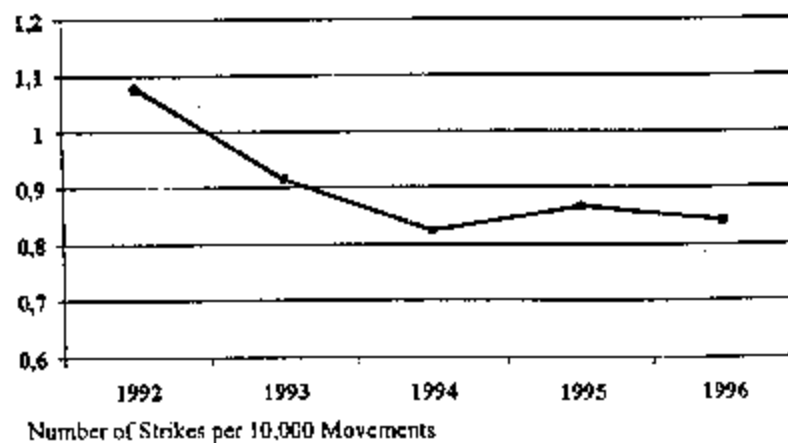
Number of Strikes per 10,000 Flying Hours



Bird Strikes CF Aerodromes

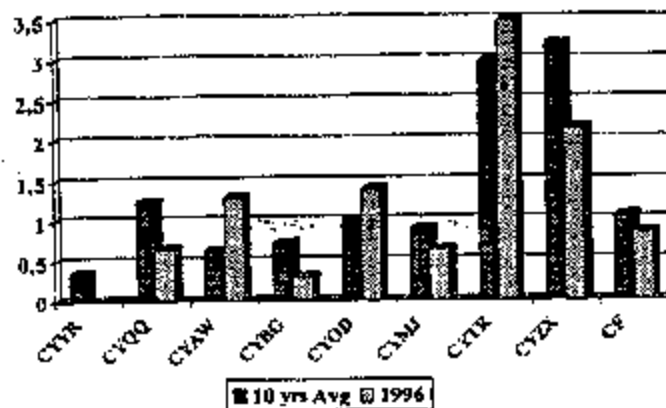


Bird Strike Rates CF Aerodromes





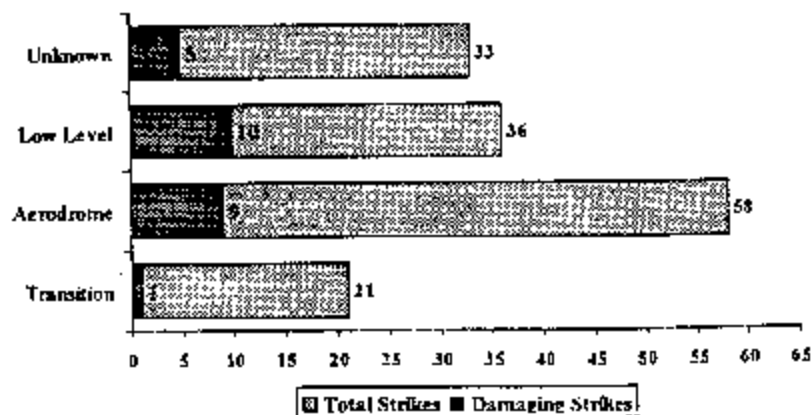
CF Bird Strikes Rate by Aerodromes



Number of Strikes per 10,000 Movements

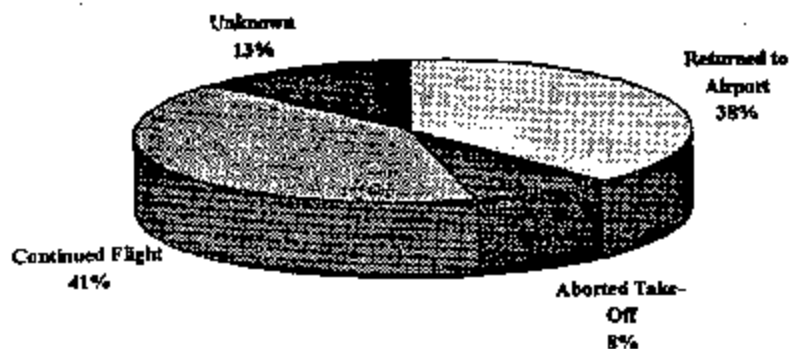


Phase of Flight

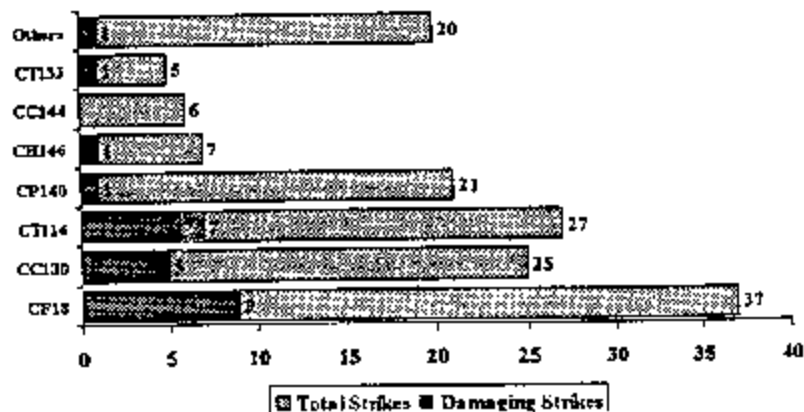




Flight Disturbance

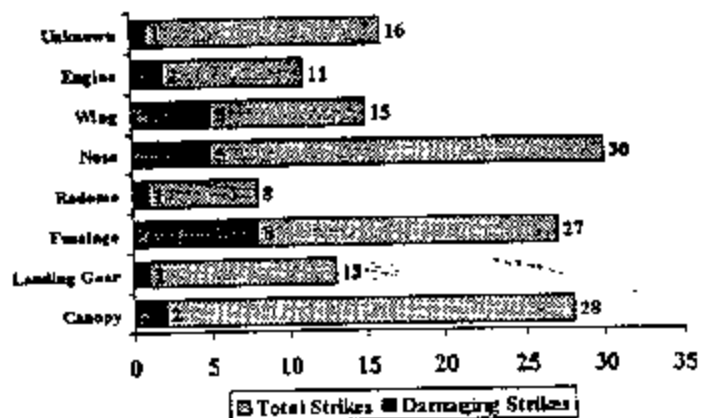


Aircraft Types

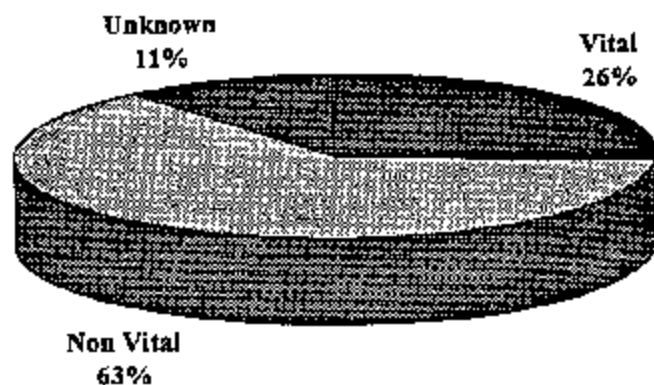




Parts Struck



Hazard Level



APPENDIX 4

1997 Bird Strike Statistics: USAF BASH Team

USAF BASH TEAM

USAF Bird Strikes 1997

2300 Bird Strikes

\$8 Million in damages

KC-135R -- Most Struck Aircraft

Horned Lark -- Most Struck Species

80% Strikes Under \$10,000

USAF BASH TEAM

MAJ PETE WINDLER	505-846-5674
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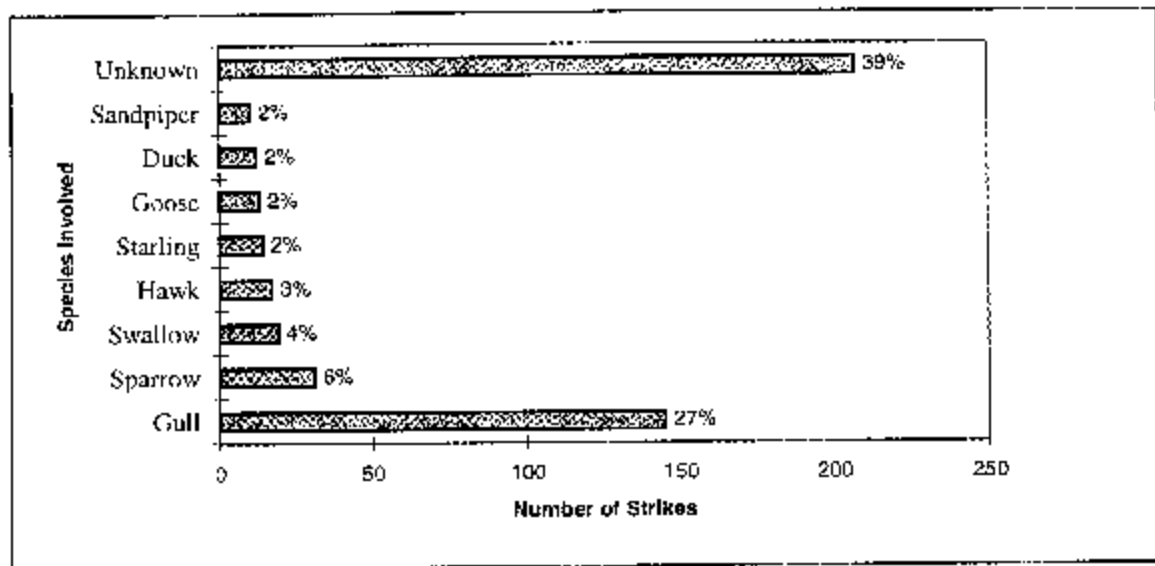
www-afsc.saia.af.mil/AFSC/Bash/home.htm

APPENDIX 5

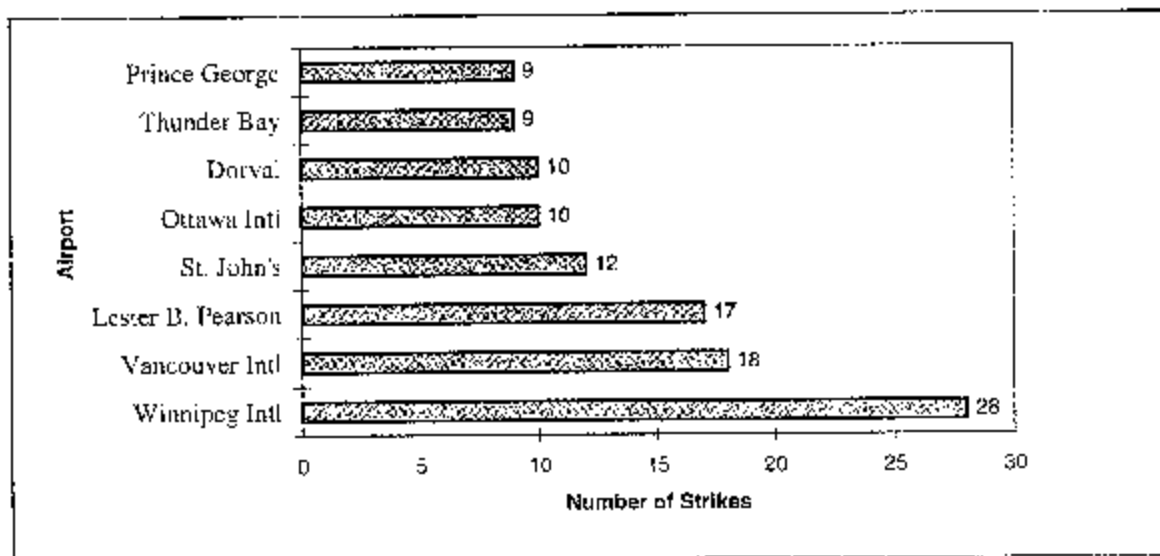
1997 Bird Strike Statistics: Transport Canada

1997 Highlights

- So far, a total of 533 bird strikes have been reported to Transport Canada in 1997. Of these, 503 occurred at Canadian sites, 16 occurred outside Canada, and 17 were of unknown origin.
- There have been 44 Precautionary Landings, 13 Aborted Takeoffs, 8 Forced Landings, and 7 Penetrated Airframes.
- Predominant bird strike species have been gulls (27%), sparrows (6%), swallows (4%), and hawks (3%). Of the strikes reported, 39% could not identify the species involved.



- Key airports include Winnipeg Intl (28 strikes), Vancouver Intl (18 strikes), and Lester B. Pearson Intl (17 strikes).



→1997 Significant Strikes→

January 2

West Jet flight 104, a Boeing 737, departing Victoria International struck an unknown bird during the takeoff roll. The impact caused a compressor stall in the number 1 engine. The takeoff was aborted, and the aircraft returned to the terminal under its own power. An engineer inspected the engine, ran tests, contacted the engine manufacturer and declared the aircraft safe to fly.

July 2

During the takeoff roll on Runway 12, Edmonton International, a West Jet Boeing 737 ingested a bird. The crew rejected the takeoff and exited the runway. Inspection revealed visible internal damage to the Number 1 engine, so the engine was subsequently changed.

[illegible]

August 18

Air Canada flight 502, a McDonnell-Douglas DC9, struck birds on takeoff from Runway 25 Thunder Bay, causing the left engine to wind down. The engine was re-lit using the igniter override; however, the engine vibrations were beyond limits so the crew shutdown the left engine and returned for an uneventful landing with ERS standing by. The left engine was found severely damaged and there were indications of other bird strikes on the aircraft although there was no other visible damage. Other bird strike locations included areas near the first officer's windscreen, and at a wing root. Feathers were also found in the intake of the right hand engine. The left engine was replaced and a full Boroscope and run-up of the right engine is being completed to ensure no damage.

→1997 Significant Strikes Cont'd→

August 21

A Cosmos Phase II ultralight aircraft was being used for bird migration experiments. Sand Hill cranes were being trained to fly in formation with the aircraft. During the flight one of the birds became tangled in the aircraft flying wires. The pilot was unable to free the bird and on the landing approach a considerable amount of his attention was on the status of the bird. On final approach the aircraft drifted to the side of the runway and the wing struck a tree. The aircraft spun around and landed hard. The pilot suffered a dislocated shoulder, the aircraft was substantially damaged, but the bird was uninjured.

September 24

The student pilot was conducting his first solo flight in a Cessna 150 when climbing out of Boundary Bay, BC, the aircraft struck a Mallard Duck. The bird penetrated the windscreen in front of right hand seat. The bird continued through the cockpit and hit rear wall.

A horizontal line of small, stylized airplane icons flying from left to right, used as a section separator.

October 6

A Piper Navajo was descending into Kamloops, BC, when the aircraft struck a Western Grebe. The bird penetrated the airframe in the tail section causing a hole 7 inches in diameter. The aircraft was able to land safely.

October 13

The pilot of a Cessna 172RG was flying a pipeline patrol out of the Brooks Airport, and was in the Lethbridge, AB, area when a Mallard Duck came through the windshield, striking the pilot. The pilot was reported to have received facial cuts and broken glasses, but was able to continue the flight to Brooks, AB, where an ambulance met the aircraft upon arrival. The pilots injuries included a broken nose and facial cuts that required stitches.

APPENDIX 6

ICAO Journal, 25(7), Sept. 1997: Bird strike analysis uses world data

Bird strike analysis uses world data

The analysis is the first to be distributed to States since ICAO's bird strike information system was upgraded in 1995.

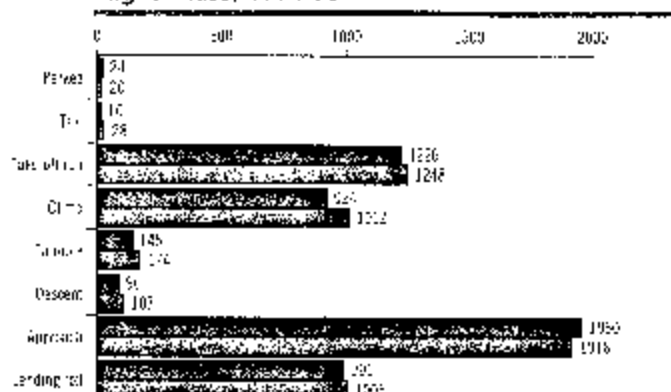
THE RESULTS of ICAO's latest bird strike analysis were disseminated recently to the civil aviation administrations of Contracting States. The report includes a world analysis and a significant strike analysis by year for the 1994-95 period, and is based on a total of 11,433 strike reports received from 45 States.

The analysis is the first to be distributed to States since ICAO's bird strike information system (IBIS) was upgraded in 1995, when IBIS was transferred from a main-frame computer to a PC-based system. The new system uses two computers for data entry and analysis, and a separate server for data storage. The ICAO analysis is performed once per year.

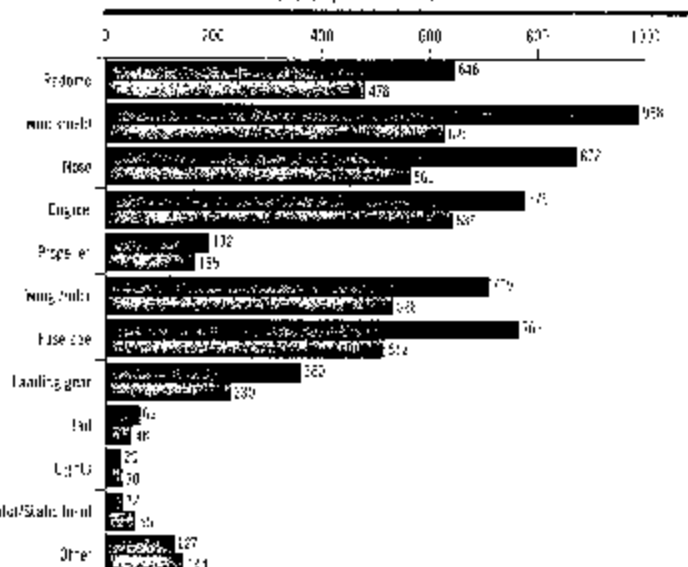
The data presented here are derived from the 1994-95 analysis and reflect incidents occurring in 137 States and territories over the two-year period. The report distributed recently to the civil aviation administrations includes a breakdown by bird species, as well a presentation of significant bird strike data.

The States which forwarded bird strike reports to ICAO over the 1994-95 period were as follows: Bangladesh, Barbados, Belgium, Brazil, Brunei Darussalam, Burundi, Canada, Chile, Cuba, Cyprus, Denmark, Fiji, Finland, France, Germany, Greece, Iceland, India, Ireland, Italy, Japan, Malaysia, Mauritius, Mexico, Niger, Norway, Oman, Pakistan, Papua New Guinea, Paraguay, Poland, Portugal, Republic of Korea, Saudi Arabia, Seychelles, South Africa, Sweden, Switzerland, Thailand, Togo, Trinidad and Tobago, the United Kingdom (including data for Hong Kong), the United States, Uruguay and Uzbekistan.

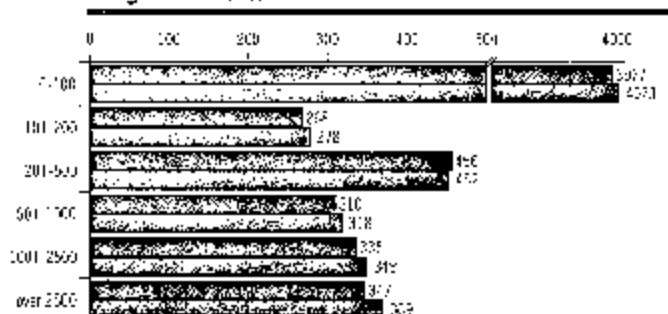
Flight Phase, 1994-95



Aircraft Parts Struck, 1994-95



Height AGL (ft), 1994-95



APPENDIX 7

1996-1997 FAA Significant Strikes

**SOME SIGNIFICANT STRIKES 1996-1997
FROM THE FAA WILDLIFE STRIKE DATABASE**

Sandra Wright
U.S. Department of Agriculture
National Wildlife Research Center
6100 Columbus Ave.
Sandusky, OH 44870

Date: 8 January 1996
Aircraft: B-737-300
Airport: Sacramento Metro
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Engine #2
Wildlife Species: Duck or goose (large)
Comments from Report: Ingested a bird in #2 engine during climb out. Vibration increased and crew throttled back and returned to land. One fan blade separated and other blades were damaged by re-ingestion of broken blade fragments. Engine was replaced.

Date: 9 January 1996
Aircraft: B-737-300
Airport: Reno/Tahoe International
Phase of Flight: Take-off
Effect on Flight: Precautionary landing & engine shut down
Damage: Engine #1
Wildlife Species: Snow goose
Comments from Report: Ingested a large bird during rotation. #1 engine failed and sparks were observed. Landed runway 16L because 16R had debris. Three fan blades were fractured with associated damage throughout the engine. The engine was replaced.

Date: 31 March 1996
Aircraft: B-737-500
Airport: Kansas City International
Phase of Flight: Take-off
Effect on Flight: Precautionary landing
Damage: Engine #2
Wildlife Species: Unknown bird (medium to large)
Comments from Report: Airport operations found a piece of inlet cooling duct on runway from a B-737-500 that had just taken off. The aircraft returned to the airport and landed safely. The engine had several damaged guide vanes and was out of service about 24 hours.

Date: 2 June 1996
Aircraft: B-737-200
Airport: Chicago Midway
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Engine #2
Wildlife Species: Gull
Comments from Report: Ingested a gull during climb out. Tower observed flames from the #2 engine and advised the pilot who declared an emergency and returned to land without further incident. Emergency equipment was on the runway. The aircraft landed using single engine landing procedures. All fan blades were damaged as well as the core. The engine had to be rebuilt.

Date: 7 August 1996
Aircraft: B-737-200
Airport: Orlando International
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Engine #2
Wildlife Species: Duck
Comments from Report: Ingested a duck during climb out. The engine began a series of compressor stalls. Time out of service was 200 hours and cost was \$1,004,000.

Date: 5 October 1996
Aircraft: B-727-200
Airport: Washington National
Phase of Flight: Climb
Effect on Flight: Precautionary landing and engine shut down
Damage: Engine #1
Wildlife Species: Gull
Comments from Report: The aircraft struck a flock of gulls just after take-off and ingested at least 1 bird. The engine began to vibrate and was shut down. A burning smell entered the cockpit. An emergency was declared and the aircraft, carrying HUD Secretary Henry Cisneros along with 52 other passengers, returned to land at Washington National. Airport Fire and Rescue was on hand. The aircraft taxied to the ramp without incident. Engine blades were damaged.

Date: November 1996
Aircraft: B-727
Airport: Chicago O'Hare International
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Window
Wildlife Species: Unknown
Comments from Report: Bird broke out pane of window. Returned to ORD from 70 miles south. Dumped 6,000 pounds of fuel. Landing uneventful.

Date: 22 November 1996
Aircraft: MD-80
Airport: Sacramento International
Phase of Flight: Climb
Effect on Flight: Precautionary landing & engine shut down
Damage: Engine #2
Wildlife Species: Gulls
Comments from Report: Several gulls were ingested just after take-off causing the engine to loose power. Engine was shut down and an emergency was declared. The plane was forced to land much heavier than usual because of a full fuel load. There were no injuries and passengers were transferred to a replacement jet. Fan blades were damaged as well as the engine. Runway was closed for approximately 1/2 hour.

Date: 7 January 1997
Aircraft: MD-82
Airport: Dallas -Fort Worth
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Engine #1 & wing
Wildlife Species: Blackbirds (437)
Comments from Report: Aircraft struck over 400 birds just after take-off. Almost every part of the plane was hit. Pilot declared an emergency and returned to land without event. Substantial damage was found on various parts of the aircraft. The #1 engine had to be replaced. Runway was closed for an hour. Personnel were sent to disperse another large flock on the airfield.

Date: 26 January 1997
Aircraft: B-737-300
Airport: Orlando International
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Engine #1
Wildlife Species: Sandhill crane
Comments from Report: The aircraft was at 900 feet after departing MCO when the strike occurred totally destroying the #1 engine.

Date: 28 February 97
Aircraft: Beechcraft 1900
Airport: Charleston/AFB International
Phase of Flight: Approach
Effect on Flight: None
Damage: Windshield
Wildlife Species: Egret or Heron (large white)
Comments from Report: The windshield on the right side shattered. Co-pilot received minor facial abrasions from glass and needed medical attention to remove glass fragments from eyes.

Date: 3 May 1997
Aircraft: DC-9
Airport: Akron-Canton Regional
Phase of Flight: Take-off
Effect on Flight: Aborted take-off
Damage: Windshield
Wildlife Species: Blackbirds
Comments from Report: Struck a flock of blackbirds causing major cockpit damage when the windshield broke. Canceled flight. Pilot had broken nose and cut forehead.

Date: 4 May 1997
Aircraft: Cessna 90 King Air
Airport: Orlando Executive
Phase of Flight: Approach
Effect on Flight: Nearly stalled below 150 ft.
Damage: Radome, nose, & prop
Wildlife Species: Large flocking birds
Comments from Report: Over 1,000 large birds covered first 1,000 ft of runway. Pilot struck between 11 and 100 of them which caused a low altitude stall with miraculous recovery. The aircraft bounced 4 times upon landing. Pilot believes there was insufficient notification and supervision of the condition on the airport.

Date: 19 June 1997
Aircraft: RV 6 - Experimental
Airport: Bountiful Skypark
Phase of Flight: Climb
Effect on Flight: Crash landing
Damage: Entire aircraft
Wildlife Species: Homing pigeon
Comments from Report: The aircraft had a bird strike through the canopy which started to break apart. The pilot was forced to land in a nearby hayfield. Most of the damage occurred during landing and tip-over. The hay was 2-3 ft tall. The pilot sustained facial lacerations which required stitches. Time out of service about 6 months and cost to repair \$30,000.

Date: 17 July 1997
Aircraft: Mitsubishi MU-2
Airport: Hardin County (Kenton, OH)
Phase of Flight: Take-off
Effect on Flight: Aborted take-off
Damage: Radome, nose, #1 & #2 engines, prop, landing gear, tail & wings.
Wildlife Species: Geese
Comments from Report: Birds were on the ground extending across the runway and about 50 ft to each side in a line. Repairs took about 50 days and cost over \$110,000.

Date: 23 July 1997
Aircraft: Beechcraft 58
Airport: Mid-America Industrial (Pryor, OK)
Phase of Flight: Landing roll
Effect on Flight: None
Damage: Radome, engines #1 and #2, prop & landing gear
Wildlife Species: Deer
Comments from Report: During the landing roll a small herd of deer ran across the runway, directly in front of the plane. One was struck by the nose wheel then bounced against the nose links causing it to collapse. With the nose on the ground, both props struck the ground. Time out of service was 3 months and cost of repairs was \$80,000.

Date: 21 August 1997
Aircraft: B-737
Airport: Portland International (OR)
Phase of Flight: Climb
Effect on Flight: Precautionary landing
Damage: Radome, nose, #1 engine
Wildlife Species: Mallard ducks
Comments from Report: The pilot reported striking 12-15 large birds at 1400 ft. Aircraft returned and landed safely. Radome and all engine fan blades were replaced. Time out of service was 15 hours and cost over \$100,000.

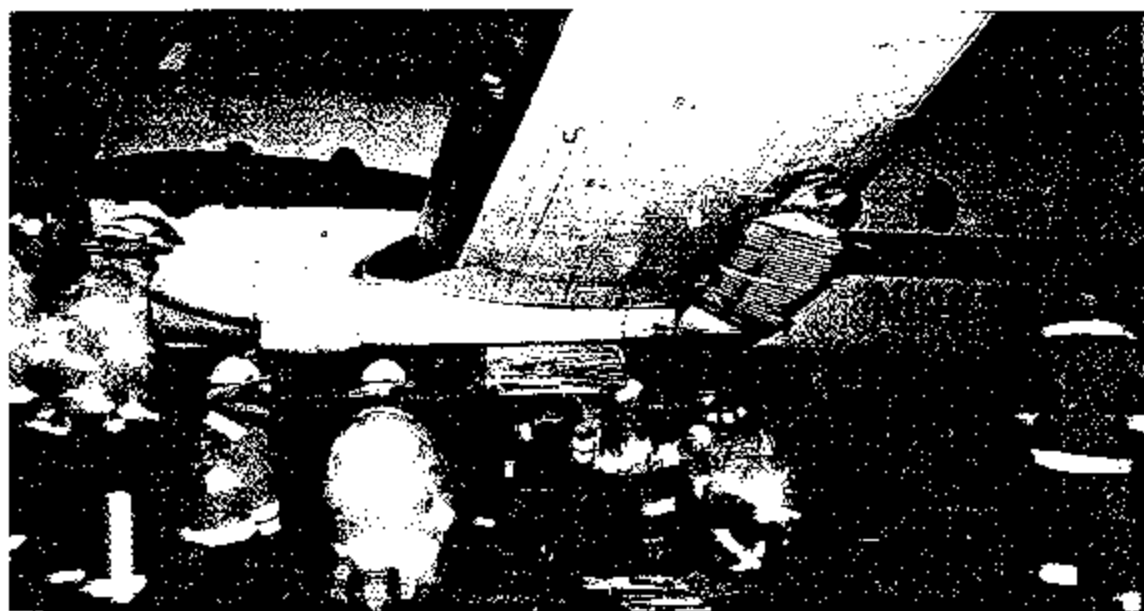
APPENDIX 8

FAA Report: Wildlife Strikes to Civil Aircraft in the U.S. 1992-1996



U. S. DEPARTMENT
OF TRANSPORTATION
FEDERAL AVIATION
ADMINISTRATION

WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES 1992-1996



AUGUST, 1997

FEDERAL AVIATION
ADMINISTRATION

WILDLIFE AIRCRAFT
STRIKE DATABASE

Serial Report -
Number 3

REPORT PREPARED BY

Edward C. Cleary

Sandra E. Wright

Richard A. Dolbeer

REPORT OF THE ASSOCIATE
ADMINISTRATOR OF AIRPORTS

OFFICE OF AIRPORT SAFETY
AND STANDARDS

AIRPORT SAFETY/OPERATIONS
DIVISION

WASHINGTON, DC

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COVER:

This Beechcraft-1900 struck a deer when landing at Latrobe, PA, December, 1996, causing the collapse of the left landing gear. All 19 passengers and crew safely deplaned. Photo courtesy of Jerry Wright, Air Line Pilots Association (ALPA).

All future reports will feature one or more pictures of aircraft damage resulting from a wildlife strike. Those with quality pictures of wildlife aircraft damage are encouraged to submit them to one of the authors for consideration. No slides, please, as they are too difficult to reproduce in this format. Full credit will be given for all pictures used.

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ACKNOWLEDGMENTS

The dBase file and support programs used to enter and organize strike data were established by *J. Rapol* and *E. LeBoeuf*, Federal Aviation Administration (FAA), Office of Airport Safety and Standards, Washington, DC. The assistance provided by the above acknowledged professionals is greatly appreciated. *T. H. Hupf* and *S. Agrawal*, FAA Technical Center, Atlantic City, New Jersey, also provided critical support and advice as did USDA biologists *H. A. Bohe*, and *C. P. Dwyer*. Finally, we acknowledge the pilots, mechanics, tower control personnel, and other members of the aviation community who reported wildlife strikes. Sponsorship and funds for the ongoing maintenance of the FAA Wildlife Strike Database are provided by the FAA, Office of Airport Safety and Standards, Washington, DC and Airports Division, Airport Technology Branch, FAA Technical Center, Atlantic City International Airport, New Jersey.

WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES 1992-1996

SYNOPSIS

Wildlife strikes to civil aircraft are a serious economic and safety problem in the United States. The Federal Aviation Administration (FAA) has a standard form (5200-7) for the voluntary reporting of bird and other wildlife strikes with aircraft. Although FAA personnel have monitored these reports since 1965 to determine general patterns in wildlife strikes, no quantitative analyses of these data were conducted until 1995.

The United States Department of Agriculture's (USDA) National Wildlife Research Center, through an interagency agreement with the FAA, initiated a project to obtain more objective estimates of the magnitude and nature of the wildlife strike problem nationwide for civil aviation in April, 1995. This project includes 1) editing all strike reports (FAA Form 5200-7) sent to the FAA since 1990 to ensure consistent, error-free data; 2) entering all edited strike reports since 1990 in a Wildlife Strike Database; 3) supplementing FAA-reported strikes with additional, non-duplicating strike reports from other sources; 4) providing FAA with an updated computer file each quarter containing all edited strike reports; and 5) assisting the FAA with the production of annual reports summarizing the results of the analyses. Such analyses are critical to determine the economic cost of wildlife strikes, the magnitude of safety issues, and most importantly, the nature of the problems (e.g., bird species, aircraft and engine types, airports, seasonality) so that corrective actions can be taken.

The first annual report on wildlife strikes to civil aircraft in the USA, covering 1994, was completed in November, 1995 (Dolbeer et al., 1995). A second report, summarizing data for the 3-year period, 1993-1995, was completed in December, 1996 (Cleary et al., 1996). It is the intention of the FAA to publish a detailed report covering the 10-year period, 1990-1999, in the year 2000. Subsequent detailed reports will be produced at 5-year intervals. In the interim years, annual reports summarizing data in tabular and graphic form for all available years will be produced.

This publication presents a synopsis of data on wildlife strikes to United States civil aircraft for the years 1992-1996. Unless noted, all numbers are totals for the 5-year period, and percentages are of the known total. For the 5-year period, 11,571 (avg. 2,314/year) strikes were reported to the FAA. Most reports were filed using FAA Form 5200-7 (Table 1). Pilots and tower personnel filed 28% and 17% of the reports, respectively (Table 2). About 75% of the reported strikes involved commercial aircraft; the remainder involved business, private and miscellaneous aircraft (Table 3).

Reports were received from all 50 States, some US territories, and from foreign countries when US registered aircraft were involved. Tables 4A and 4B show the distribution of reported bird and mammal strikes for the various states and territories.

Most bird strikes (51%) occurred between July and October (Table 5); 63% occurred during the day (Table 6); 34% occurred when the aircraft was on approach; and 21% occurred during take-off (Table 7). Fifty-five percent of the bird strikes occurred when the aircraft was at an altitude of less than 100 ft. above ground level (AGL), 79% occurred under 900 ft. AGL, and 88% occurred under 2,000 ft. AGL (Table 8).

Most mammal strikes (45%) occurred in the fall (Table 5); 58% occurred at night (Table 6); 50% occurred when the aircraft was landing; 30% occurred during take-off; and 9% occurred while the aircraft was still in the air, when the aircraft struck deer with the landing gear or encountered bats (Table 7).

Aircraft types most often involved in strikes that had a negative effect on flight were Boeing 737, McDonnell-Douglas MD-80, British Aerospace Jetstream, Douglas Corp. DC-9, Cessna 172, and Beechcraft-1900 (Table 9A). These aircraft types also headed the list of those most often involved in a strike that damaged one or more aircraft components or caused a loss of time or money (Table 9B).

Aircraft components most commonly reported as struck by birds were windshield, engine, nose, and wing/rotor. Those components most often reported as damaged were engine, wing/rotor, radome, and windshield (Table 10A). Aircraft components most commonly reported as struck by mammals were: landing gear, propeller, wing/rotor, engine, and fuselage. These same components headed the list for the parts most often reported as damaged (Table 10B). Table 11 shows the reported effect-on-flight of wildlife strikes to US civil aircraft. Fourteen percent of the bird, and 47% of the mammal, strike reports indicated the strike had a negative effect on the flight.

Birds were involved in 97% of the reported strikes, mammals in 3%, and <1% involved reptiles. Gulls, blackbirds, waterfowl, doves, and raptors were the most commonly struck bird groups (Table 12A). The most commonly struck mammals were deer and coyotes (Table 12B). Gulls were involved in almost three times as many strikes as waterfowl, but both were involved in essentially the same number of damaging strikes (Table 13).

For the 5-year period, 16% (1,840) of the reported bird, and 51% (161) of the reported mammal strikes caused damage to the aircraft. Of these 2,001 reports, 476 reports estimated aircraft down time (total = 96,593 hours, avg. = 203 hours/report) (Table 14A), and 371 reports estimated the monetary losses (total = \$40,083,368, avg. = \$108,041/report) (Table 14B). Analysis of strike reports from three major US airports showed that less than 20% of all strikes occurring at these airports were reported to FAA. Additionally, many reports received by FAA were filed before aircraft damage had been fully

assessed. For these reasons, the information on the number of strikes and their associated costs compiled from the voluntary reporting program is believed to underestimate the magnitude of the problem.

Assuming all 2,001 aircraft reporting strike damage incurred similar amounts of down time and monetary losses, and that these reports represented all of the damaging strikes that occurred, then at a minimum, wildlife aircraft strikes cost the US civil aviation industry 81,241 hours/year of aircraft down time and \$43.2 million/year in direct monetary losses.

Further, assuming a 20% reporting rate, the cost of wildlife aircraft strikes to the US civil aviation industry is estimated to be in excess of 406,000 hours/year of aircraft down time and \$216 million/year in direct monetary losses.

For the most part, airport wildlife management programs have focused on gulls, because this group of birds is most often involved in wildlife strikes. However, the strike data for 1992-1996 indicate that airports should also focus on species such as waterfowl, raptors, and wading birds, as well as deer.

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Table 1. Sources of information for reported wildlife strikes to civil aircraft, USA, 1992-1996.

Source	Number of reported strikes						5-yr avg.	% of total
	Years							
	1992	1993	1994	1995	1996	Total		
AAIPN ¹	11	17	5	8	5	46	9	<1
AC Incident Report	86	106	77	55	75	409	82	4
Airport Report	22	91	48	67	102	330	66	3
ASRS ²	14	8	17	13	5	57	11	<1
Daily Alert Bulletin	4	3	1	0	0	8	2	<1
Engine Mfg.	1	2	1	63	24	91	18	1
FAA Form 5200-7	1,895	1,795	1,833	1,843	1,785	9,151	1,830	79
Multiple	129	139	180	190	298	936	187	8
NTSB ³	3	2	2	1	1	9	2	<1
Other	39	36	39	82	131	327	65	3
PACIR ⁴	2	12	22	78	75	189	38	2
Unknown	9	0	0	6	3	18	4	<1
Total	2,215	2,211	2,225	2,416	2,504	11,571	2,314	100

1. Alaska Aircraft Incident Preliminary Notice

2. Aviation Safety Reporting Service

3. National Transportation Safety Board

4. Preliminary Aircraft Incident Report

Table 2. Person filing report of wildlife strike to civil aircraft, USA, 1992-1996.

Person filing report	Number of reported Strikes						5-yr. avg.	% of total
	Year							
	1992	1993	1994	1995	1996	Total		
Aircraft Maint.	10	3	12	6	5	36	7	<1
Carcass Found	63	109	50	91	134	447	89	4
Operations	25	36	56	44	47	208	42	2
Other	1,077	1,115	1,156	1,354	1,430	6,132	1,226	53
Pilot	649	555	561	505	516	2,786	558	24
Tower	382	392	387	409	364	1,934	387	17
Unknown	9	1	3	7	6	26	5	<1
Total	2,215	2,211	2,225	2,416	2,504	11,571	2,314	100

Table 3. Number of reported wildlife strikes to civil aircraft by type of operator, USA, 1992-1996.

Operator	Number of reported strikes						5-yr. avg.	% of total
	Year							
	1992	1993	1994	1995	1996	Total ^a		
Commercial	1,660	1,637	1,694	1,822	1,821	8,634	1,727	75
Business	282	227	290	328	368	1,515	303	13
Private	121	155	139	116	96	627	125	5
Gov / Police	9	6	11	11	6	43	9	<1
Unknown	143	186	91	139	193	752	150	6
Total	2,215	2,211	2,225	2,416	2,504	11,571	2,314	100

Table 4A. Number of reported bird strikes to civil aircraft by US State, including Puerto Rico (PR) and the US Virgin Islands (VI), 1992-1996.

State	Number of reported strikes					Total	5-yr. avg	% of total
	Years							
	1992	1993	1994	1995	1996			
AK	21	10	17	22	20	90	18	0.9
AL	22	21	60	30	29	162	32	1.4
AR	20	10	14	16	11	71	14	0.6
AZ	5	12	14	17	35	78	16	0.7
CA	189	209	223	258	211	1,098	218	9.7
CO	19	19	20	15	25	101	20	0.9
CT	43	23	33	23	36	166	33	1.5
DC	42	44	61	56	60	283	57	2.5
DE	1	1	6	1	1	10	2	0.1
FL	146	140	167	188	188	827	165	7.3
GA	47	28	66	48	51	241	48	2.1
HI	21	24	17	35	93	210	42	1.9
IA	22	23	20	24	14	103	21	0.9
ID	4	2	5	10	5	26	5	0.2
IL	96	173	123	147	156	595	119	6.2
IN	22	23	18	31	15	110	22	1.0
KS	6	10	8	11	6	45	9	0.4
KY	65	74	66	54	55	314	63	2.8
LA	63	75	48	71	69	321	64	2.9
MA	32	40	28	29	29	158	32	1.4
MD	31	26	29	33	27	146	29	1.3
ME	15	10	6	17	9	57	11	0.5
MI	50	53	40	33	42	218	44	1.9
MN	18	25	27	13	15	98	20	0.9
MO	32	43	34	50	51	210	42	1.9
MS	7	14	11	6	15	53	11	0.5
MT	7	6	2	4	3	22	4	0.2
NC	61	47	72	73	49	302	60	2.7
ND	8	3	8	8	4	23	5	0.2
NE	26	27	34	25	16	128	26	1.1
NH	4	9	14	8	6	41	8	0.4
NJ	74	75	80	97	80	396	79	3.5
NM	4	3	4	10	6	27	5	0.2
NV	5	2	9	11	14	41	8	0.4
NY	148	139	121	138	176	722	144	6.4
OH	55	83	77	84	95	398	80	3.5
OK	14	14	11	9	9	57	11	0.5
OR	22	27	20	24	31	124	25	1.1
PA	120	101	107	122	110	560	112	5.0
PR	2	4	0	5	8	19	4	0.2
RI	6	7	9	6	2	32	6	0.3
SC	11	12	12	15	14	64	13	0.6
SD	3	0	4	5	10	22	4	0.2
TN	80	62	45	54	62	303	61	2.7
TX	210	194	173	158	172	913	183	5.1
UT	32	32	25	21	23	133	27	1.2
VA	55	42	52	57	55	261	52	2.3
VI	5	4	5	8	4	24	5	0.2
VT	2	1	2	2	1	8	2	0.1
WA	21	57	41	46	63	228	46	2.0
WI	42	21	13	26	22	124	25	1.1
WV	14	10	10	10	8	52	10	0.5
WY	3	1	2	0	0	6	1	0.1
Totals								
US States & territories	2,090	2,110	2,119	2,260	2,330	10,909	2,182	96.9
Fgn/Unk ¹	71	47	36	92	98	344	69	3.1
All reported strikes	2,161	2,157	2,155	2,352	2,428	11,253	2,251	100

¹ Strikes involving US registered aircraft that occurred outside of US territory, or for which the state where it occurred was not given.

Table 4B. Number of reported mammal strikes to civil aircraft by US State, including Puerto Rico (PR) and the US Virgin Islands, 1992-1996.

State	Number of strikes					Total	5-yr avg	% of total
	Years							
	1992	1993	1994	1995	1996			
AK	0	1	0	1	0	2	<1	0.6
AL	1	1	0	0	1	3	1	1.0
AR	0	0	2	2	4	9	2	2.9
AZ	2	2	1	1	2	9	2	2.9
CA	2	0	1	4	2	9	2	2.9
CO	0	0	1	2	0	3	1	1.0
CT	2	2	0	2	2	8	2	2.5
DC	0	0	0	1	4	5	1	1.0
DE	0	0	1	0	0	1	<1	0.3
FL	0	0	2	2	2	6	1	1.9
GA	1	2	1	1	0	5	1	1.6
HI	1	0	0	0	0	1	<1	0.3
IA	0	2	0	0	0	2	<1	0.6
ID	1	0	0	0	1	2	<1	0.6
IL	3	9	3	8	7	30	6	9.9
IN	1	1	2	1	0	5	1	1.6
KS	1	0	0	0	0	1	<1	0.3
KY	0	0	0	1	0	1	<1	0.3
LA	0	0	0	0	2	2	<1	0.6
MA	2	0	0	0	2	4	1	1.3
MD	0	0	2	4	3	9	2	2.9
ME	1	0	0	1	0	2	<1	0.6
MI	2	0	8	2	3	15	3	4.8
MN	2	0	0	0	2	4	1	1.3
MO	1	1	3	0	0	5	1	1.6
MS	0	0	1	0	1	2	<1	0.6
MT	0	0	0	1	0	1	<1	0.3
NC	1	0	4	1	3	9	2	2.9
ND	0	0	0	0	0	0	0	0.0
NE	2	1	0	0	1	4	1	1.3
NH	0	0	2	1	0	3	1	1.0
NJ	3	3	6	0	6	18	4	5.7
NM	0	0	0	0	1	1	<1	0.3
NV	0	0	0	1	1	2	<1	0.6
NY	5	3	4	5	3	20	4	6.3
OH	3	2	1	1	0	7	1	2.2
OK	0	1	1	0	1	3	1	1.0
OR	0	0	0	1	1	2	<1	0.6
PA	6	7	6	5	2	26	5	9.2
PR	0	1	0	3	0	4	<1	0.3
RI	0	0	0	0	0	0	0	0.0
SC	0	0	0	0	1	1	<1	0.3
SD	0	0	0	0	0	0	<1	0.6
TN	0	0	0	1	2	3	1	1.0
TX	3	5	4	5	4	21	4	7.0
UT	0	1	0	0	0	1	<1	0.3
VA	0	1	0	4	5	10	2	3.2
VI	0	0	0	0	0	0	0	0.0
VT	0	0	0	0	0	0	0	0.0
WA	0	0	0	1	1	2	<1	0.6
WI	1	1	4	0	1	7	1	2.2
WV	6	3	5	2	5	21	4	6.7
WY	0	1	1	0	0	2	<1	0.6
Totals								
US States & territories	53	54	58	63	76	314	63	99.7
Fgn/Unk ¹	0	0	1	0	0	1	<1	0.3
All reported strikes	53	54	59	63	76	315	63	100.0

¹ Strikes involving US registered aircraft that occurred outside of US territory, or for which the state where it occurred was not given.

Table 5. Number of reported wildlife strikes to civil aircraft by month, USA, 1992-1996.
See also Figures 1 and 2.

Month	Number of reported strikes					Total	5-yr. avg.	% of total
	Years							
	1992	1993	1994	1995	1996			
Birds								
Jan.	75	95	89	99	108	466	93	4
Feb.	84	94	74	73	94	419	84	4
Mar.	110	131	119	156	125	641	128	6
Apr.	126	180	147	149	158	760	152	7
May	206	195	172	215	219	1 007	201	9
Jun.	193	157	137	156	165	808	162	7
Jul.	221	227	223	243	250	1 164	233	10
Aug.	353	287	302	296	316	1 554	311	14
Sep.	298	327	312	286	327	1 550	310	14
Oct.	241	248	267	332	326	1 414	283	13
Nov.	152	123	202	215	198	890	178	8
Dec.	99	93	111	132	142	577	115	5
Unk	3	0	0	0	0	3	1	<1
Total	2,161	2,157	2,155	2,352	2,428	11,253	2,251	100
Mammals								
Jan.	2	3	2	2	3	12	2	4
Feb.	1	1	2	1	1	6	1	2
Mar.	1	1	6	10	3	21	4	7
Apr.	2	4	1	3	2	12	2	4
May	3	4	3	0	5	15	3	5
Jun.	5	8	4	5	10	32	6	10
Jul.	5	5	5	5	5	25	5	8
Aug.	2	1	3	5	14	25	5	8
Sep.	9	7	7	9	9	41	8	13
Oct.	8	8	12	8	9	45	9	14
Nov.	12	8	17	9	12	58	12	18
Dec.	3	4	7	6	3	23	5	7
Total	53	54	69	63	76	315	63	100

Table 6. Reported time of occurrence of wildlife strikes to civil aircraft, USA, 1992-1996. See also Figures 3A, 3B, 4A, and 4B.

Time	Number of reported strikes						5-yr. avg.	% of total
	Year							
	1992	1993	1994	1995	1996	Total		
Birds								
Dawn	80	81	71	106	112	450	90	4
Day	1,410	1,346	1,405	1,432	1,464	7,057	1,411	63
Dusk	86	122	137	113	125	583	117	5
Night	534	515	485	558	543	2,635	527	23
Not reported	51	93	57	143	184	528	106	5
Total	2,161	2,157	2,155	2,352	2,428	11,253	2,251	100
Mammals								
Dawn	2	2	0	1	1	6	1	2
Day	8	21	9	14	17	69	14	22
Dusk	10	2	5	7	7	31	6	10
Night	29	25	50	34	44	182	36	56
Not reported	4	4	5	7	7	27	5	9
Total	53	54	69	63	76	315	63	100

Table 7. Reported phase of flight at time of wildlife strikes to civil aircraft, USA, 1992-1996.

Phase of flight	Number of reported strikes						5-yr. avg	% of total
	Year							
	1992	1993	1994	1995	1996	Total		
Birds								
Parked	3	0	-	3	1	8	2	<1
Taxiing	10	9	9	12	9	49	10	<1
Take-off	366	601	456	450	445	2,318	464	21
Climb	369	143	345	403	403	1,663	333	15
En route	78	75	72	80	75	380	76	3
Descent	72	68	66	92	76	374	75	3
Approach	811	762	713	779	792	3,857	771	34
Landing roll	352	344	399	348	371	1,812	362	16
Not reported	100	155	94	187	256	792	158	7
Total	2,161	2,157	2,155	2,352	2,428	11,253	2,251	100
Mammals								
Parked	0	0	0	0	0	0	0	0
Taxiing	1	0	0	0	0	1	<1	<1
Take-off	15	12	26	20	20	93	19	30
Climb	0	0	0	0	2	2	<1	1
En route	0	0	1	0	0	1	<1	<1
Descent	1	0	0	0	0	1	<1	<1
Approach	4	9	2	6	4	25	5	8
Landing roll	29	25	37	29	38	158	32	50
Not reported	3	8	3	8	12	34	7	11
Total	53	54	69	63	76	315	63	100

Table 8. Number of reported bird strikes to civil aircraft by altitude (feet) above ground level (AGL), USA, 1992-1996. See also Figure 5.

Number of reported strikes											
Years											
Altitude of strike (feet AGL)	1992	1993	1994	1995	1996	Total	5-yr. avg.	% of total known	Cumul. % of total known		
0 to 0	729	627	816	718	822	3,712	742	39	39		
1 to 99	340	303	272	309	289	1,513	303	16	55		
100 to 199	130	125	140	133	126	654	131	7	62		
200 to 299	94	94	94	102	69	453	91	5	67		
300 to 399	76	53	65	68	58	320	64	3	70		
400 to 499	23	49	29	36	37	174	35	2	72		
500 to 599	61	59	57	60	73	310	62	3	76		
600 to 699	22	21	18	17	19	97	19	1	77		
700 to 799	15	14	16	13	18	76	15	1	77		
800 to 899	36	19	33	25	30	143	29	2	79		
900 to 999	9	11	4	14	7	45	9	<1	79		
1,000 to 1,499	103	97	99	95	96	490	98	5	85		
1,500 to 1,999	65	66	53	64	54	302	60	3	88		
2,000 to 2,999	80	69	64	112	93	418	84	4	92		
3,000 to 3,999	46	47	40	25	59	217	43	2	95		
4,000 to 4,999	20	26	25	61	30	162	32	2	96		
5,000 to 5,999	21	6	29	14	31	101	20	1	97		
6,000 to 6,999	16	30	16	5	19	86	17	1	98		
7,000 to 7,999	14	2	7	16	9	48	10	1	99		
8,000 to 8,999	8	6	3	9	4	32	6	<1	99		
9,000 to 9,999	4	4	6	2	3	19	4	<1	99		
10,000 to 14,999	19	10	10	12	17	58	14	1	100		
15,000 to 19,999	1	0	0	0	0	1	<1	<1	100		
20,000 to 29,999	0	1	0	2	2	5	1	<1	100		
30,000 to 33,000	1	0	0	1	0	2	<1	<1	100		
Total known	1,933	1,741	1,896	1,913	1,965	9,448	1,890	100			
Total unknown	228	416	259	439	463	1,805	361				
Grand total	2,161	2,157	2,155	2,352	2,428	11,253	2,251				

Table 9A. Number of reported strikes that had a negative effect on flight by most commonly involved aircraft type, USA, 1992-1996.

		Number of reported strikes							
		Years							
Aircraft	Engine ¹	1992	1993	1994	1995	1996	Total	5-yr. avg.	% of total
B-737	TF/TJ	36	80	61	56	72	305	61	19
MD-80	TF	13	25	15	18	15	86	17	5
DC-9	TF	2	16	16	18	17	69	14	4
B-757	TF	7	16	12	11	3	49	10	3
B-727	TJ	5	17	9	4	11	46	9	3
B-747	TF	11	15	5	10	8	49	10	3
Citation	TF	6	7	8	7	4	32	6	2
FK-100	TF	3	4	7	4	3	21	4	1
BA-Jetstream	TP	14	22	19	15	16	86	17	5
C-172	PS	12	13	14	6	5	50	10	3
BE-1900	TP	3	15	4	11	9	42	8	3
PA-28	PS	4	12	12	8	7	43	9	3
SAAB-340	TP	7	13	10	10	11	51	10	3
BE-55 Baron	PS	4	10	6	4	7	31	6	2
C-152	PS	3	8	3	5	4	23	5	1
ATR-42	TP	3	7	3	7	4	24	5	1
Other/unknown		78	184	113	141	125	641	128	39
Total		211	464	317	335	321	1,648	330	100

¹ TF = Turbo-fan; TJ = Turbo-jet; TP = Turbo-prop; PS = Piston

Table 9B. Number of reported strikes that damaged one or more aircraft components, or that resulted in lost time or money, by most commonly involved aircraft type, USA, 1992-1996.

		Number of reported strikes							
		Years							
Aircraft	Engine ¹	1992	1993	1994	1995	1996	Total	5-yr. avg.	% of total
B-737	TF/TJ	52	59	75	101	111	398	80	20
MD-80	TF	21	17	22	23	19	102	20	5
DC-9	TF	10	14	19	25	20	88	18	4
B-757	TF	9	14	12	24	15	74	15	4
B-727	TJ	11	14	14	16	15	70	14	3
B-747	TF	15	13	6	14	10	58	12	3
Citation	TF	8	5	12	15	4	44	9	2
FK-10C	TF	4	4	6	8	9	31	6	2
BA-Jetstream	TP	26	19	22	14	14	95	19	5
C-172	PS	16	10	15	11	11	63	13	3
BE-1900	TP	8	12	9	13	14	56	11	3
PA-28	PS	1	10	8	6	14	39	8	2
SAAB-340	TP	6	4	7	9	10	36	7	2
BE-55 Baron	PS	6	9	7	4	6	32	6	2
C-152	PS	6	3	2	9	3	23	5	1
ATR-42	TP	5	5	6	4	2	22	4	1
Other/unknown		123	141	156	176	181	777	155	39
Total		327	353	398	472	458	2,008	402	100

¹ TF = Turbo-fan; TJ = Turbo-jet; TP = Turbo-prop; PS = Piston

Table 10A. Civil aircraft components reported as being struck and damaged by birds, USA, 1992-1996.

Parts of aircraft	Number of reported strikes					Total	5-yr. avg.
	Year						
	1992	1993	1994	1995	1996		
Radome							
Struck	195	200	225	255	238	1,113	223
Damaged	24	25	40	47	35	171	34
Windshield							
Struck	344	265	405	401	401	1,816	363
Damaged	28	25	38	42	30	163	33
Nose							
Struck	225	253	265	307	300	1,350	270
Damaged	17	26	19	18	30	110	22
Engine							
Struck	267	252	297	391	336	1,543	309
Damaged	100	113	123	154	151	641	128
Propeller							
Struck	86	74	84	97	74	415	83
Damaged	7	12	9	6	8	42	8
Wing/rotor							
Struck	243	244	258	313	282	1,340	268
Damaged	83	86	89	111	78	447	89
Fuselage							
Struck	224	213	230	223	253	1,143	229
Damaged	12	10	10	10	17	59	12
Landing Gear							
Struck	104	90	123	129	111	557	111
Damaged	16	9	15	17	14	71	14
Tail							
Struck	26	25	27	38	41	157	31
Damaged	10	12	13	15	18	68	14
Light							
Struck	11	23	18	18	15	85	17
Damaged	8	21	15	16	11	71	14
Other							
Struck	58	86	92	111	64	411	82
Damaged	24	40	43	47	28	182	36

Table 10B. Civil aircraft components reported as being struck and damaged by mammals, USA, 1992-1996.

Parts of aircraft	Number of reported strikes					Total	5-yr. avg.
	Year						
	1992	1993	1994	1995	1996		
Radome							
Struck	0	0	2	1	0	3	1
Damaged	0	0	2	0	0	2	<1
Windshield							
Struck	1	0	1	3	0	5	1
Damaged	0	1	1	1	0	3	1
Nose							
Struck	1	3	3	4	2	13	3
Damaged	1	3	3	3	2	12	2
Engine							
Struck	3	2	6	4	7	22	4
Damaged	3	2	5	3	6	19	4
Propeller							
Struck	6	2	12	12	15	47	9
Damaged	5	3	12	8	14	42	8
Wing/rotor							
Struck	3	4	12	5	13	37	7
Damaged	3	3	12	5	13	36	7
Fuselage							
Struck	1	3	8	5	5	22	4
Damaged	0	3	7	5	4	19	4
Landing Gear							
Struck	10	15	28	22	19	94	19
Damaged	10	11	15	15	17	68	14
Tail							
Struck	5	0	3	2	6	16	3
Damaged	5	1	4	1	5	16	3
Light							
Struck	0	2	2	0	1	5	1
Damaged	0	1	2	0	1	4	1
Other							
Struck	3	10	18	4	10	45	9
Damaged	3	10	15	4	11	43	9

Table 11. Reported effect-on-flight of wildlife strikes to civil aircraft, USA, 1992-1996.

Effect on flight	Number of reported strikes						5-yr. avg.	% of total
	Year							
	1992	1993	1994	1995	1996	Total		
Birds								
None	1,446	1,540	1,703	1,762	1,475	7,926	1,585	70
Aborted take-off	51	52	64	64	85	316	63	3
Engine shut down	15	8	12	16	11	62	12	1
Precautionary landing	85	117	109	123	156	590	118	5
Other	38	255	97	104	39	533	107	5
Not reported	526	185	170	283	662	1,626	365	16
Total	2,161	2,157	2,155	2,352	2,428	11,253	2,251	100
Mammals								
None	9	12	20	24	14	79	16	25
Aborted take-off	6	3	11	8	9	37	7	12
Engine shut down	1	1	0	1	0	3	1	1
Precautionary landing	1	2	5	7	5	20	4	6
Other	14	26	19	12	16	87	17	28
Not reported	22	10	14	11	32	89	18	28
Total	53	54	69	63	76	315	63	100

Table 12 A. Identified bird groups most commonly involved in reported wildlife strikes to civil aircraft, USA, 1992-1996.

Bird groups	Number of reported strikes					Total	5-yr. avg.	% of total
	Year							
	1992	1993	1994	1995	1996			
Gulls	366	351	314	314	333	1,678	336	31
Waterfowl	107	142	145	131	140	665	133	12
Ducks	51	66	63	46	65	291	58	5
Geese/swans	56	76	82	85	75	374	75	7
Blackbirds	139	144	131	128	140	682	136	13
Blackbirds	65	89	73	85	76	408	82	8
Starling	54	55	58	43	64	274	55	5
Doves	107	111	135	110	132	595	119	11
Rock	49	39	38	52	45	223	45	4
Mourning	58	72	97	58	87	372	74	7
Raptors	94	90	112	124	110	530	106	10
Hawks	46	51	71	82	64	304	61	6
Owls	25	24	15	21	32	117	23	2
Eagles	2	2	5	4	4	18	4	<1
Vultures	21	13	20	17	20	91	18	2
Sparrows ¹	83	89	89	80	82	423	85	8
Corvids	17	22	27	32	14	112	22	2
Shorebirds	19	19	30	26	35	129	26	2
Cormorants	3	-	6	1	5	10	2	<1
Pelicans	4	-	3	3	2	13	3	<1
Plovers	2	-	2	3	9	17	3	<1
Killdeer	8	12	16	13	14	63	13	1
Scaup	2	4	9	6	5	26	5	<1
Wading birds	15	26	20	24	35	120	24	2
Egrets	10	17	13	15	18	73	15	1
Heron	3	6	8	5	10	30	6	-
Cranes	2	3	1	4	7	17	3	<1
Swallows	24	31	23	30	24	132	26	2
Misc. birds	20	72	65	56	85	298	60	6
Totals								
Known birds	991	1,097	1,091	1,055	1,130	5,364	1,073	100
Unknown birds	1,170	1,060	1,064	1,297	1,298	5,889	1,178	
Reported strikes	2,161	2,157	2,155	2,352	2,428	11,253	2,251	

¹ Some of the birds identified on strike reports as "sparrows" probably belong to other groups such as snow buntings, finches, juncos, etc.

Table 12 B. Identified mammal and reptile groups most commonly involved in reported wildlife strikes to civil aircraft, USA, 1992-1996.

Mammal groups	Number of reported strikes					Total	5-yr. avg.	of total
	Years							
	1992	1993	1994	1995	1996			
Ungulates	44	36	55	36	54	225	45	72
Deer	42	33	54	34	51	214	43	68
Elk	-	0	1	0	2	4	1	1
Cattle	-	2	0	1	1	5	1	2
Pronghorn	0	1	0	1	0	2	<1	1
Carnivores	5	6	13	19	21	64	13	20
Coyote	1	4	10	11	9	35	7	11
Dog	1	0	1	4	4	10	2	3
Fox	1	0	1	2	4	8	2	3
Raccoon	0	2	1	1	0	4	1	1
Cat	2	0	0	0	0	2	<1	1
Striped skunk	0	0	0	1	4	5	1	2
Rodents	1	4	0	4	0	9	2	3
Muskrat	0	0	0	1	0	1	<1	<1
Woodchuck	1	4	0	3	0	8	2	3
Bats	2	6	1	3	0	12	2	4
Opossum	0	2	0	1	1	4	1	1
Rabbit	1	0	0	0	0	1	<1	<1
Total mammal strikes	53	54	69	63	76	315	63	100
Reptiles	1	0	1	1	0	3	1	100
Alligator	0	0	1	0	0	1	<1	33
Turtle	1	0	0	1	0	2	<1	67
Total reptile strikes	1	0	1	1	0	3	1	

Table 13. Number of reported wildlife strikes causing damage to civil aircraft by wildlife group, USA, 1992-1996.

Wildlife group	Number of reported strikes					Total	5-yr. avg.	% of total
	Years							
	1992	1993	1994	1995	1996			
Birds								
Gulls	62	81	57	59	59	328	66	16
Waterfowl	52	68	64	70	57	311	62	16
Blackbirds	7	21	9	8	6	51	10	3
Doves	7	24	15	16	14	76	15	4
Raptors	28	37	41	29	29	164	33	8
Corvids	2	1	6	5	1	15	3	1
Wading birds	2	11	4	3	8	28	6	1
Misc. birds	7	16	12	7	9	51	10	3
Unknown birds	108	184	129	206	189	816	163	41
Total birds	275	443	337	413	372	1,840	368	92
Mammals								
Ungulates	24	24	37	28	41	154	31	8
Carnivores	1	2	1	1	1	6	1	<1
Bats	0	0	1	0	0	1	<1	<1
Total mammals	25	26	39	29	42	161	32	8
Grand total	300	469	376	442	414	2,001	400	100

Table 14A. Reported aircraft down time (hours) resulting from wildlife strikes to civil aircraft, USA, 1992-1996¹

Wildlife group	Reported down time (hrs)					Total	5-yr. avg.	% of total
	Years							
	1992	1993	1994	1995	1996			
Birds								
Gulls	290	7,864	517	1,370	614	10,655	2,131	11
Waterfowl	2,940	2,504	2,373	3,038	2,670	13,825	2,765	14
Blackbirds	2	83	769	4	150	1,008	202	1
Doves	30	12	24	39	110	215	43	<1
Raptors	1,268	705	4,021	1,394	3,518	10,906	2,181	11
Corvids	0	0	73	3	0	76	15	<1
Wading birds	0	1,387	0	49	326	1,762	352	2
Misc. birds	1,306	8	888	7	51	2,260	452	2
Unknown	93	2,398	173	1,453	2,705	6,822	1,364	7
Total bird	5,929	14,961	8,838	7,357	10,444	47,529	9,506	49
Mammals								
Ungulates	2,920	3,602	25,668	152	8,796	41,138	8,228	43
Carnivores	0	0	5,760	2,160	6	7,926	1,585	8
Total mammal	2,920	3,602	31,428	2,312	8,802	49,064	9,813	51
Grand total	8,849	18,563	40,266	9,669	19,246	96,593	19,319	100

¹ For the 5-year period, 16% (1,840) of the reported bird, and 51% (161) of the reported mammal, strikes caused damage to the aircraft. Of these 2,001 reports, 476 estimated aircraft down time and 371 estimated the monetary losses.

Table 14B. Reported monetary losses (cost of damage, lost revenue, and other monetary losses) in US dollars, resulting from wildlife strikes to civil aircraft, USA, 1992-1996¹

Wildlife group	Reported monetary losses (\$)						5-yr. avg.	% of total
	Years							
	1992	1993	1994	1995	1996	Total		
Birds								
Gulls	905,204	434,762	722,440	718,604	547,275	3,328,285	665,657	8
Waterfowl	56,850	63,400	1,453,706	11,445,471	1,122,703	14,142,130	2,828,426	35
Blackbirds	200	7,900	463,000	11,000	29,000	511,100	102,220	1
Doves	155,661	75,100	400	1,509,900	2,500	1,743,561	348,712	4
Raptors	241,259	457,500	2,175,648	269,763	106,275	3,250,445	650,089	8
Corvids	150	0	6,805	950	0	7,905	1,581	<1
Wading birds	0	6,500	0	0	0	6,500	1,300	<1
Misc. birds	1,861,570	64,500	1,008,668	103	4,360	2,933,201	587,840	7
Unknown	3,500	3,069,779	511,000	7,291,302	1,634,562	12,510,143	2,502,029	31
Total bird	3,224,394	4,179,441	6,341,667	21,247,093	3,446,675	38,439,270	7,687,655	96
Mammals								
Ungulates	8,000	192,250	463,342	141,500	685,006	1,490,098	298,020	4
Carnivores	0	0	105,000	35,000	14,000	154,000	30,800	<1
Total mammal	8,000	192,250	568,342	176,500	699,006	1,644,098	328,820	4
Grand total	3,232,394	4,371,691	6,910,009	21,423,593	4,145,681	40,083,368	8,016,674	100

¹ For the 5-year period, 16% (1,840) of the reported bird, and 51% (161) of the reported mammal strikes caused damage to the aircraft. Of these 2,001 reports, 476 estimated aircraft down time and 371 estimated the monetary losses.

Bird Strikes to Aircraft

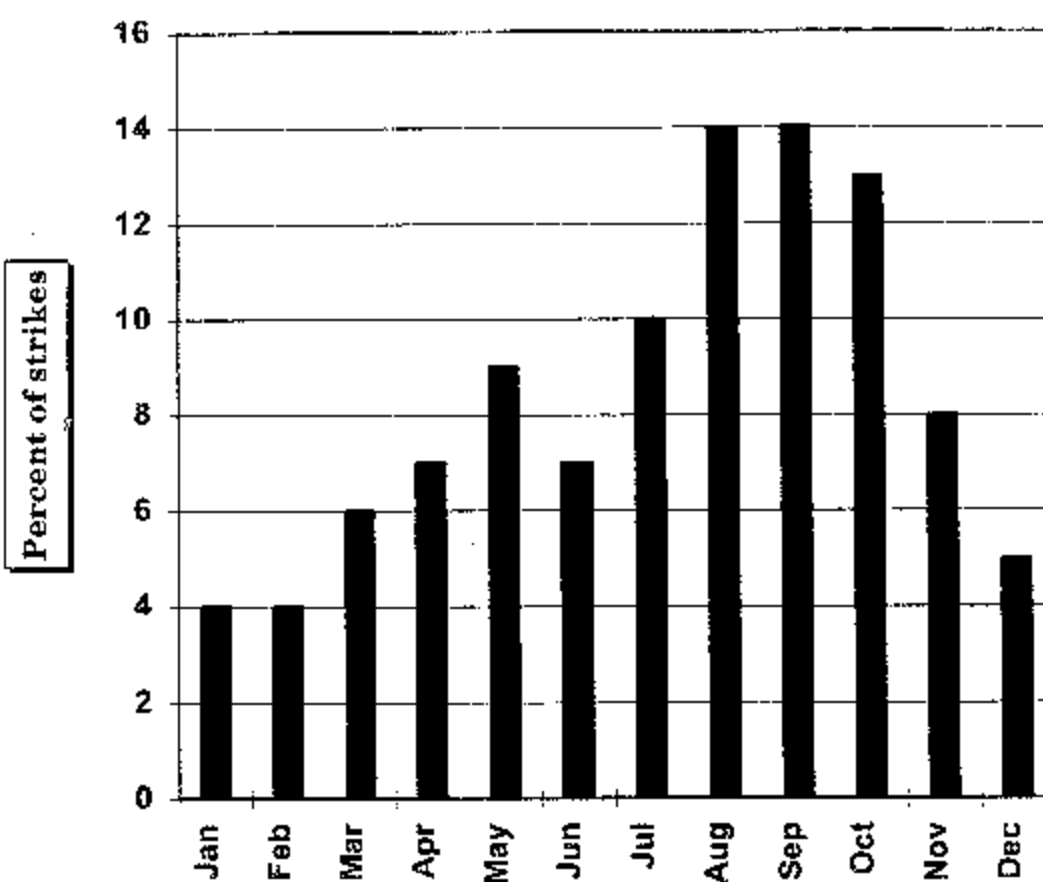


Figure 1. Percent of reported bird strikes to civil aircraft by month, USA, 1992-1996 (N = 11,253).

Mammal Strikes to Aircraft

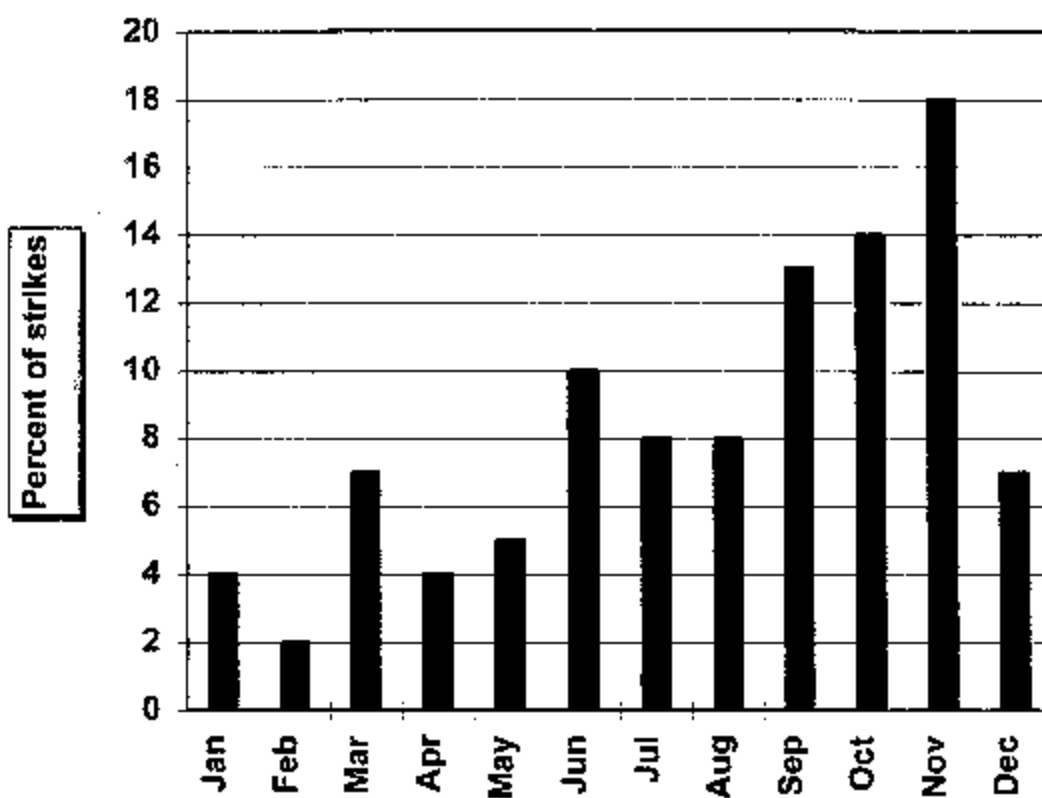


Figure 2. Percent of reported mammal strikes to civil aircraft by month, 1992-1996 (N = 315).

Time of Occurrence of Bird Strikes

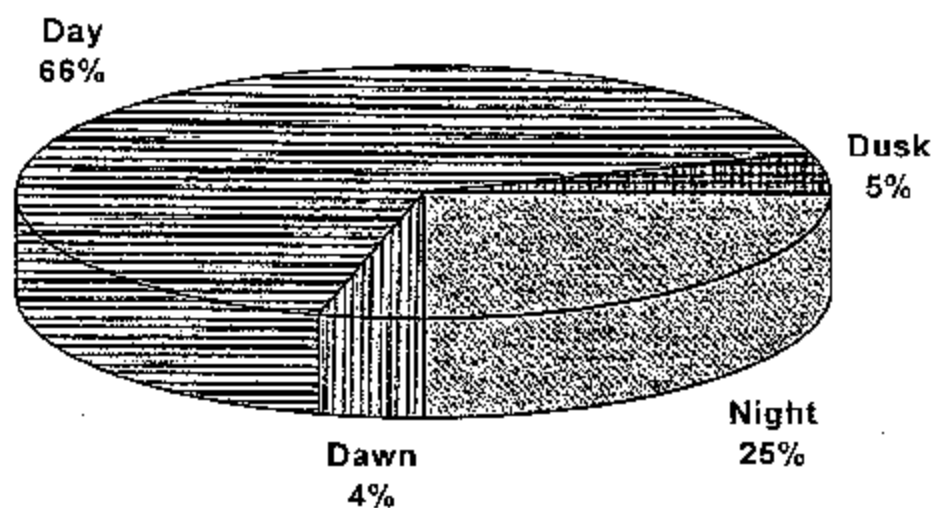


Figure 3A. Time of occurrence of reported bird strikes to civil aircraft, USA, 1992-1996.

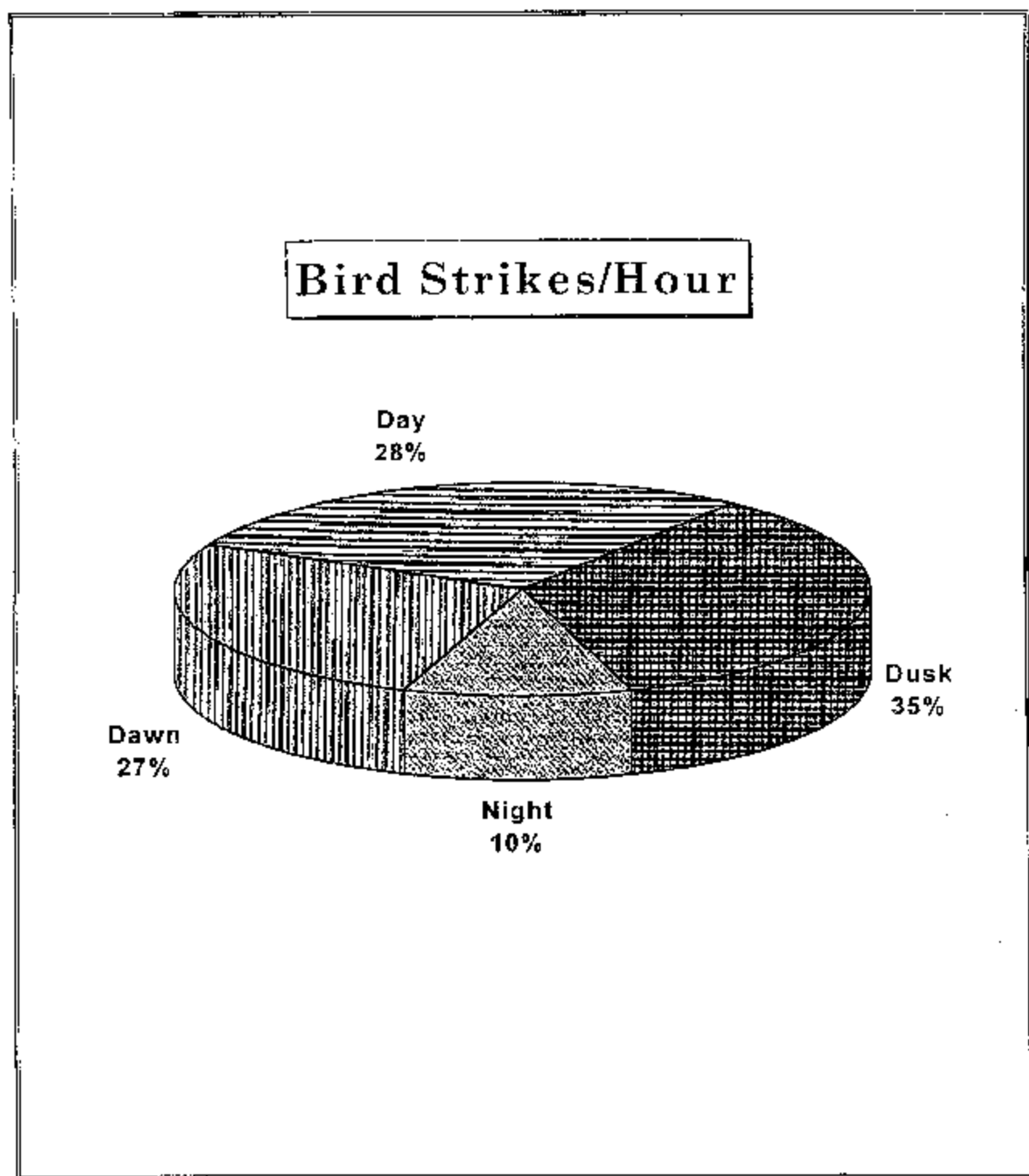


Figure 3B. Mean percentage of bird strikes/hour by time of day to civil aircraft, USA, 1992-1996. (Strikes/hour were calculated using an average day and night length of 11.25 hours, and an average dawn and dusk length of 0.75 hour, each).

Time of Occurrence of Mammal Strikes

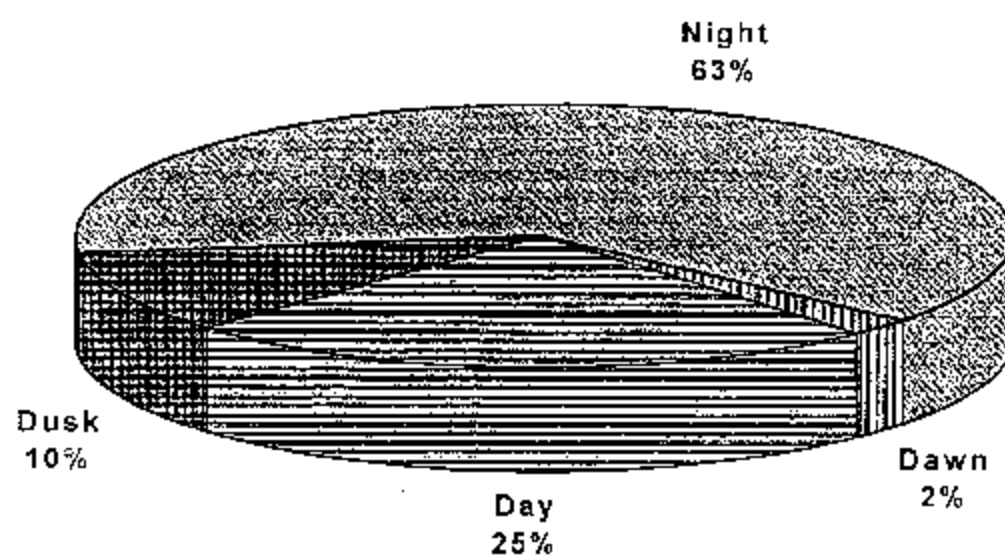


Figure 4A. Time of occurrence of reported mammal strikes to civil aircraft, USA, 1992-1996.

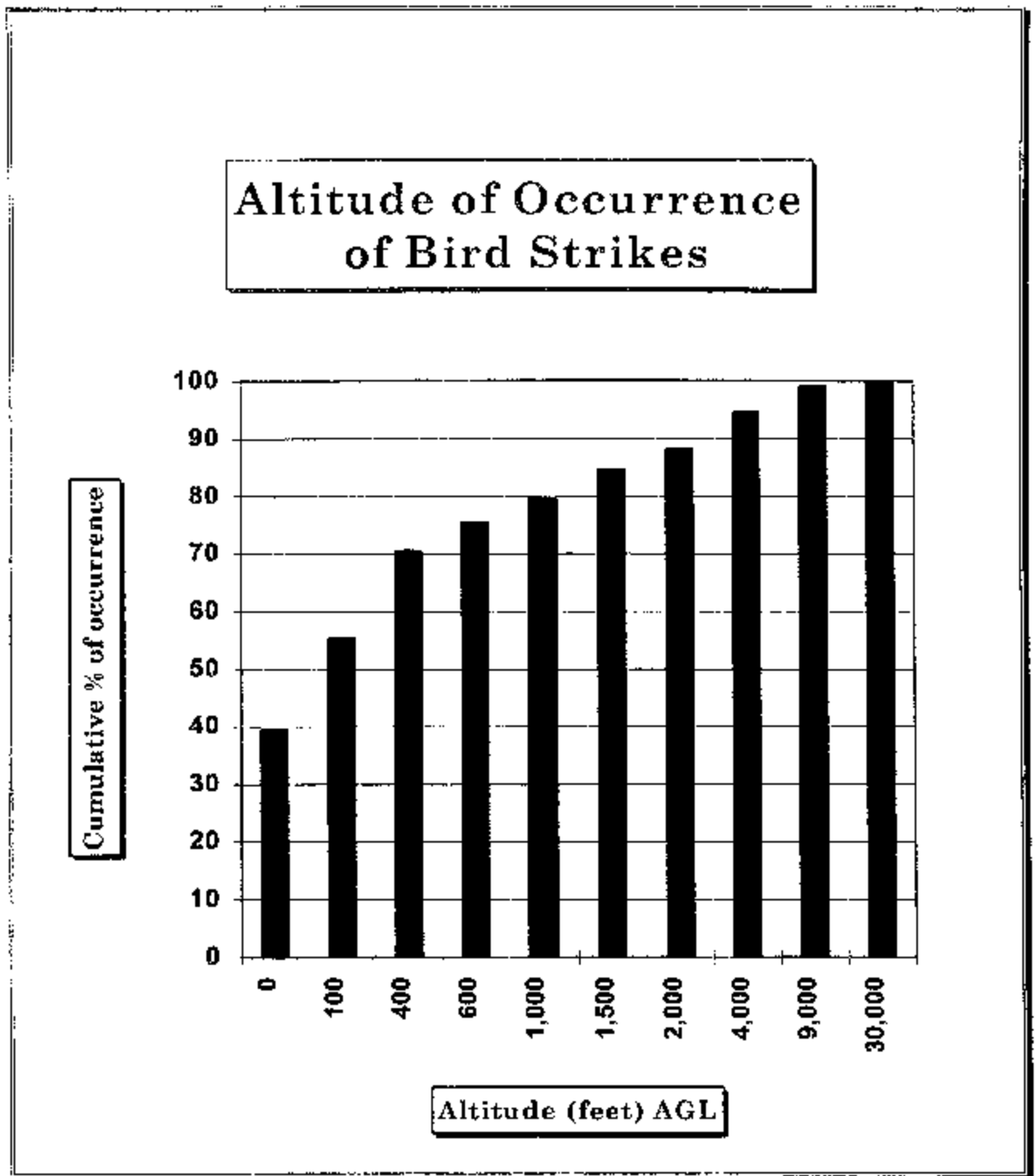


Figure 5. Cumulative percentage of reported bird strikes to civil aircraft by altitude (feet) above ground level (AGL).

APPENDIX 9

Coyotes on Airports: Safety Hazard or Unpaid Member of the Bird Strike Team?

Presented at Bird Strike Committee Canada Meeting #27

25 November 1997

Ottawa, Canada

**COYOTES ON AIRPORTS: SAFETY HAZARD OR
UNPAID MEMBER OF THE BIRD STRIKE TEAM?**

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Wildlife strikes to civil aircraft are a serious economic and safety problem in the United States. The Federal Aviation Administration (FAA) has a standard form (5200-7) for the voluntary reporting of bird and other wildlife strikes with aircraft. Although FAA personnel have monitored these reports since 1965 to determine general patterns in wildlife strikes, no quantitative analyses of these data were conducted until 1995.

The United States Department of Agriculture's National Wildlife Research Center, through an interagency agreement with the FAA, initiated a project in April 1995 to obtain more objective estimates of the magnitude and nature of the wildlife strike problem nationwide for civil aviation. This project included 1) editing all strike reports sent to the FAA since 1990 to ensure consistent, error-free data; 2) entering all edited strike reports since 1990 into a Wildlife Strike Database; 3) supplementing FAA-reported strikes with additional, non-duplicating strike reports from other sources; and 4) assisting the FAA with the production of reports summarizing results of analyses. Such analyses are critical to determine the economics of wildlife strikes, the magnitude of safety issues, and most importantly, the nature of the problems (e.g. wildlife species, aircraft and engine types, airports, seasonality) so that corrective actions can be prioritized, justified and taken.

As of November 1997, we have edited and entered about 15,000 non-duplicating records from 15 June 1991 through 31 August 1997. The following analysis provides an example of the

type of information that can be obtained from the database. Previous reports on strike hazards by deer (Wright 1996) and geese (Wright 1997) provide additional examples.

THE QUESTION: HOW HAZARDOUS ARE COYOTES ON AIRPORTS?

Coyotes are not infrequently seen on airports in the United States where they hunt for small mammals such as rabbits and voles. We have been asked by various airport personnel if benefits coyotes provide in reducing the prey base for raptors (birds of prey), which are known strike hazards, outweigh risks posed by coyotes as a strike hazard themselves. As a starting point to answering this question, we analyzed the FAA Wildlife Strike Database to determine the frequency and nature of aircraft collisions with coyotes and raptors. The information gathered should assist airport managers with decisions about controlling coyotes at airports by putting the relative hazard level created by coyotes and raptors into perspective.

We excluded ospreys and vultures from the analysis because these species typically feed on fish and carrion, respectively, and would not be influenced by the presence of small mammals and birds on airports. In addition, we excluded aircraft strikes with raptors that occurred away from the airport.

RESULTS

The database contained 45 coyote strikes and 677 raptor strikes (Table 1). Most coyote strikes occurred during take-off run (58% of the 34 records where phase of flight was reported) whereas the opposite occurred for raptors - more strikes during approach and landing roll (61% of the 546 records where phase of flight was reported) (Table 2). The greatest seasonal period for coyote strikes was July - December (83%) whereas raptor strikes were highest from July - September (46%) (Table 3).

The landing gear was the part of the aircraft most often reported as being struck (16) and damaged (4) by coyotes (Table 4). The wing was most often reported as being struck (89) and damaged (34) by raptors.

Only 7 coyote strikes had a reported effect on flight compared to 90 raptor strikes (Table 5). Coyotes caused damage in only 4 strikes whereas raptors caused damage in 90 strikes (Table 6). Only 1 coyote strike caused substantial damage (defined by the International Civil Aviation Organization [1989] as damage or structural failure which adversely affects the structure strength,

performance or flight characteristics of the aircraft and which would normally require major repair or replacement of the affected component) whereas ³² ~~31~~ raptor strikes caused substantial damage (including the destruction of 1 aircraft).

The reported cost to repair damage from coyote strikes was \$105,120 (nose gear collapsed on a Cessna 210 causing \$105,000 in damage) compared to \$2,915,896 for raptor strikes. It should be noted that only 2 of 4 coyote strike reports and 22 of 90 raptor strike reports indicating damage included cost data. Thus, the actual dollar losses, especially for raptor strikes, were much higher than these figures indicate.

Illinois was the top state for reporting both coyote (10) and raptor strikes (111) (Table 7). We caution that the number of strikes in a state is influenced by the number of aircraft movements and the reporting rate and thus does not necessarily correlate with the population levels of these wildlife species on airports.

CONCLUSIONS

Coyotes are found on airports throughout the United States with 45 strike reports received from 24 states from June 1991 - August 1997. Although the potential for damaging strikes by coyotes exists, this analysis indicates coyotes have been only a minor problem for civil aviation in the United States compared to raptors. Other wildlife species, notably gulls, waterfowl and Columbids (doves and pigeons), have also caused considerably more damage to aircraft compared to coyotes (Cleary et al. 1997). Thus, given limited resources in wildlife hazard reduction programs at airports, coyote control should be a lower priority than management efforts for those more hazardous species. Additional research is needed to determine under what circumstances, if any, coyotes can actually reduce numbers of raptors or other hazardous species on airports by feeding on rodents and other prey species.

If anyone has information on coyote strikes that they suspect is not included in this analysis, please contact the authors. Also, other information on coyote activity on airports relevant to this analysis would be appreciated. Examples might include damage coyotes have caused to airport property by chewing or digging or beneficial activities in which they affect other wildlife species.

ACKNOWLEDGMENTS

We would like to thank the following people for their assistance in providing support for this article: E.C. Cleary, FAA Office of Airport Safety and Standards, Washington, D.C. and S. Agrawal and T. Hupf, FAA Technical Center, Atlantic City, NJ.

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- . 1997. Canada geese: flying elephants we must avoid! FAA Aviation News 36(8): 1-5.

Table 1. Number of reported coyote and raptor strikes to civil aircraft in the FAA Wildlife Strike Database, June 1991-August 1997. The database contains about 15,000 strike records for this time period.

Year	Coyotes	Raptors ^a
1991	3	52
1992	1	94
1993	4	96
1994	10	97
1995	11	126
1996	11	119
1997	5	93
Total	45	677

^a Vultures and ospreys excluded as well as birds struck away from airport

Table 2. Reported phase of flight at time of coyote and raptor strikes to civil aircraft in the FAA Wildlife Strike Database, June 1991-August 1997.

Phase of flight ^a	Coyotes	Raptors
Approach	1	164
Landing roll	13	171
Taxi	0	3
Take-off run	20	133
Climb	0	75
Not reported	11	131
Total	45	677

^a Strikes en route and during descent excluded because strikes did not occur in vicinity of airport.

Table 3. Number of reported coyote and raptor strikes to civil aircraft by month in the FAA Wildlife Strike Database, July 1991-June 1997.

Month	Coyotes		Raptors	
	Number	% of total	Number	% of total
Jan	2	5	41	6
Feb	2	5	37	6
Mar	2	5	46	7
Apr	0	0	31	5
May	1	3	39	6
Jun	0	0	39	6
Jul	4	10	124	19
Aug	7	18	95	15
Sep	6	15	79	12
Oct	7	18	48	7
Nov	5	13	37	6
Dec	4	10	37	6
Total	40		653	

Table 4. Part of aircraft struck and damaged by coyote and raptor strikes to civil aircraft in the FAA Wildlife Strike Database, June 1991-August 1997.

Part of aircraft	Coyotes		Raptors	
	Struck	Damaged	Struck	Damaged
Wing	0	0	89	34
Engine	2	1	68	35
Windshield	0	0	65	8
Nose	0	0	53	5
Fuselage	2	0	47	1
Propeller	2	1	39	4
Landing gear	16	4	38	2
Radome	0	0	34	13
Tail	0	0	10	3
Lights	0	0	3	2
Other	1	1	26	9
Not reported	26		357	
Total ^a	49	7	829	82

^a Several strike reports had multiple parts of aircraft hit.

Table 5. Effect on flight of coyote and raptor strikes to civil aircraft in the FAA Wildlife Strike Database, June 1991-August 1997.

Effect on flight	Coyotes	Raptors
None	18	382
Not reported	20	205
Precautionary landing	2	26
Other	2	33
Aborted take-off	3	28
Engine shut down	0	3
Total	45	677

Table 6. Extent of damage reported from coyote and raptor strikes to civil aircraft in the FAA Wildlife Strike Database, June 1991-August 1997.

Extent of damage	Coyotes	Raptors
None	26	376
Unknown	15	211
Some- Extent unknown	0	7
Minor	3	51
Substantial	1	31
Destroyed	0	1
Total	45	677

Table 7. Number of reported coyote and raptor strikes to civil aircraft by state in the FAA Wildlife Strike Database, June 1991-August 1997.

Coyotes		Raptors	
State ^a	No. of strikes	State ^a	No. of strikes
IL	10	IL	111
AR	5	CA	76
CA	2	NJ	47
CO	2	NY	36
DC	2	FL	32
OH	2	HI	29
TX	2	PA	26
WA	2	KY	23
MO	2	OR	21
AZ	1	TX	20
FL	1	OH	19
GA	1	TN	18
IA	1	WI	18
ID	1	MO	14
KS	1	LA	14
KY	1	MI	13
NH	1	NC	13
NM	1	VA	13
NV	1	AK	10
NY	1	DC	10
OK	1	IN	9
OR	1	WA	9
TN	1	IA	7
WI	1	NE	7
		22 other states	73
Total	44 ^b		661 ^b

^a The number of strikes reported by state are influenced by the reporting rate and the number of aircraft movements and thus do not necessarily correlate with the population levels of these wildlife species on airports.

^b Location of strike not listed in 1 coyote and 17 raptor strike reports.

APPENDIX 10

Shooting Gulls to Reduce Strikes with Aircraft at J.F.K. International Airport, 1991-1997 (Draft Report)

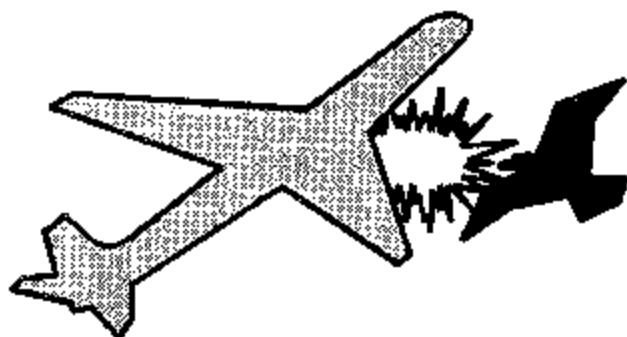
SHOOTING GULLS TO REDUCE STRIKES WITH AIRCRAFT AT JOHN F. KENNEDY
INTERNATIONAL AIRPORT, 1991-1997 (DRAFT REPORT)

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National Wildlife Research Center, 6100 Columbus Avenue, Sandusky, Ohio 44870

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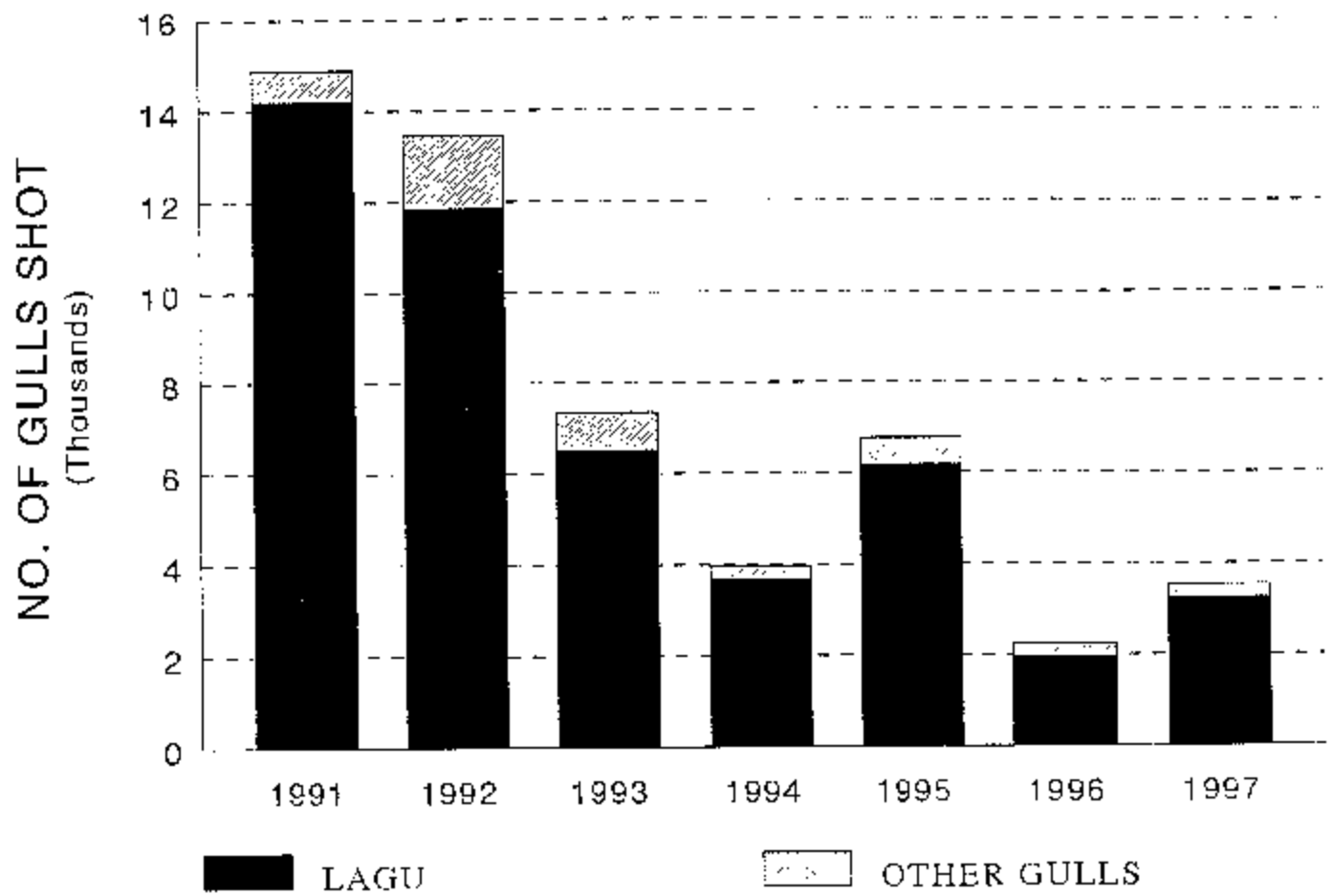
ABSTRACT: The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York. Laughing gulls (Larus arcticus) accounted for 52% of the bird strikes (an aircraft striking ≥ 1 bird) from 1988-1990, averaging 157 strikes/year. This species is present from May-September in association with a 7,633-nest colony (1990) in Jamaica Bay adjacent to the airport. A program to reduce gull collisions with aircraft was undertaken from May-August 1991-1997 in which 2-5 people stationed on airport boundaries used shotguns to shoot gulls flying over the airport. In 6,369 person-hours of shooting, 52,235 gulls were killed (14,856, 13,466, 7,340, 3,981, 6,759, 2,263, and 3,540 in 1991-1997, respectively), comprised of 47,601 laughing gulls and 4,634 other gulls. The number of aircraft striking laughing gulls during the shooting period (20 May-15 Aug) declined by 66% in 1991 and 76-89% in 1992-1997, compared with the mean of 136 strikes during the same time period for 1988-1990. Strikes by the other gull species were reduced by a comparable amount. In spite of the removal of 47,601 laughing gulls in 1991-1997 (about 3 1/2 times the number of adults in the Jamaica Bay colony in 1990), the nesting colony declined by only 58% from 1990-1997 (7,629 to 3,241 nests). Our recommended long term solution is to relocate the nesting colony away from JFKIA. A seasonal shooting program, coupled with other management programs to deter gulls from the airport, should continue to minimize the number of gull-aircraft collisions until this relocation is achieved.

EVALUATION OF SHOTGUN SHOOTING
TO REDUCE AIRCRAFT STRIKES BY
GULLS AT
J. F. K. INTERNATIONAL AIRPORT
1991-1997



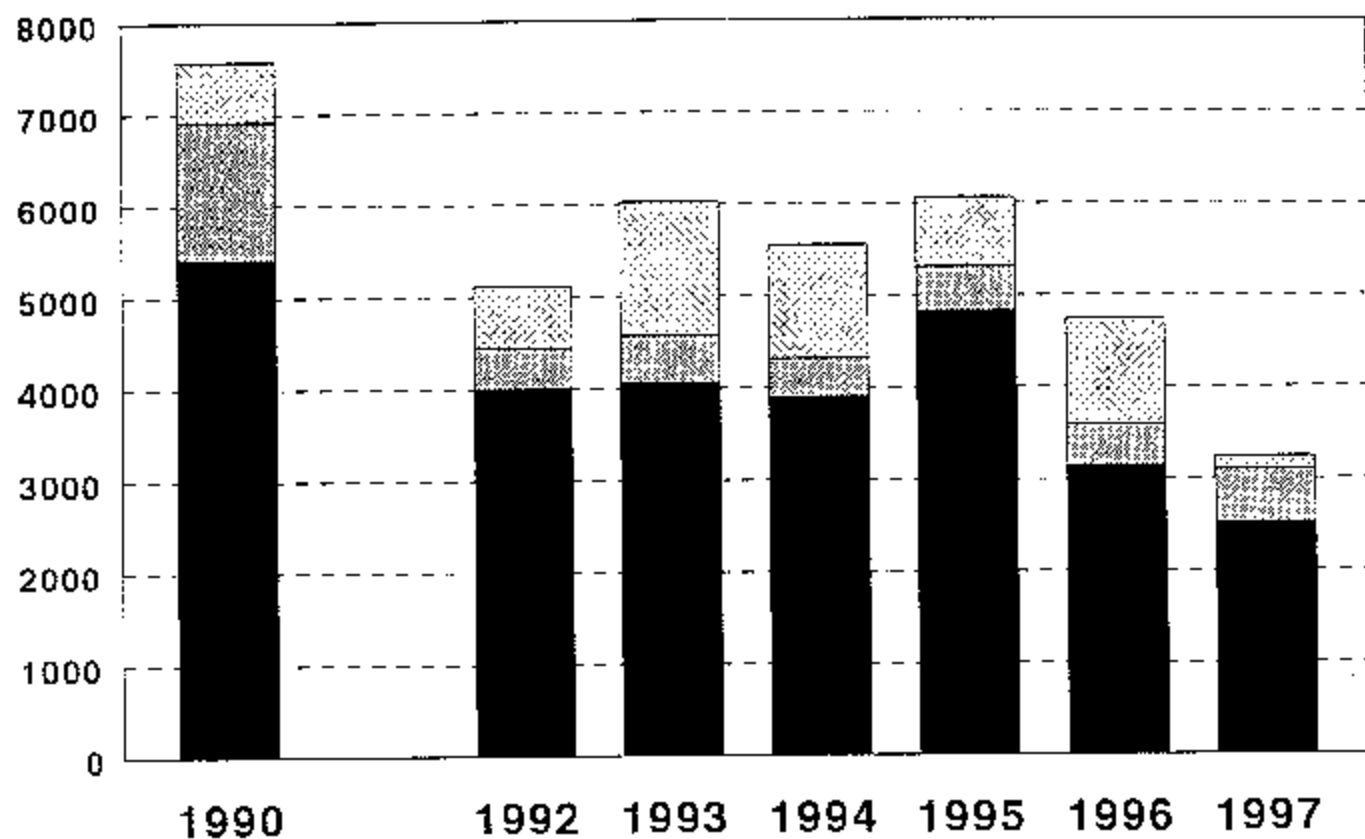
U. S. DEPARTMENT OF AGRICULTURE
IN COOPERATION WITH
THE PORT AUTHORITY OF
NEW YORK AND NEW JERSEY

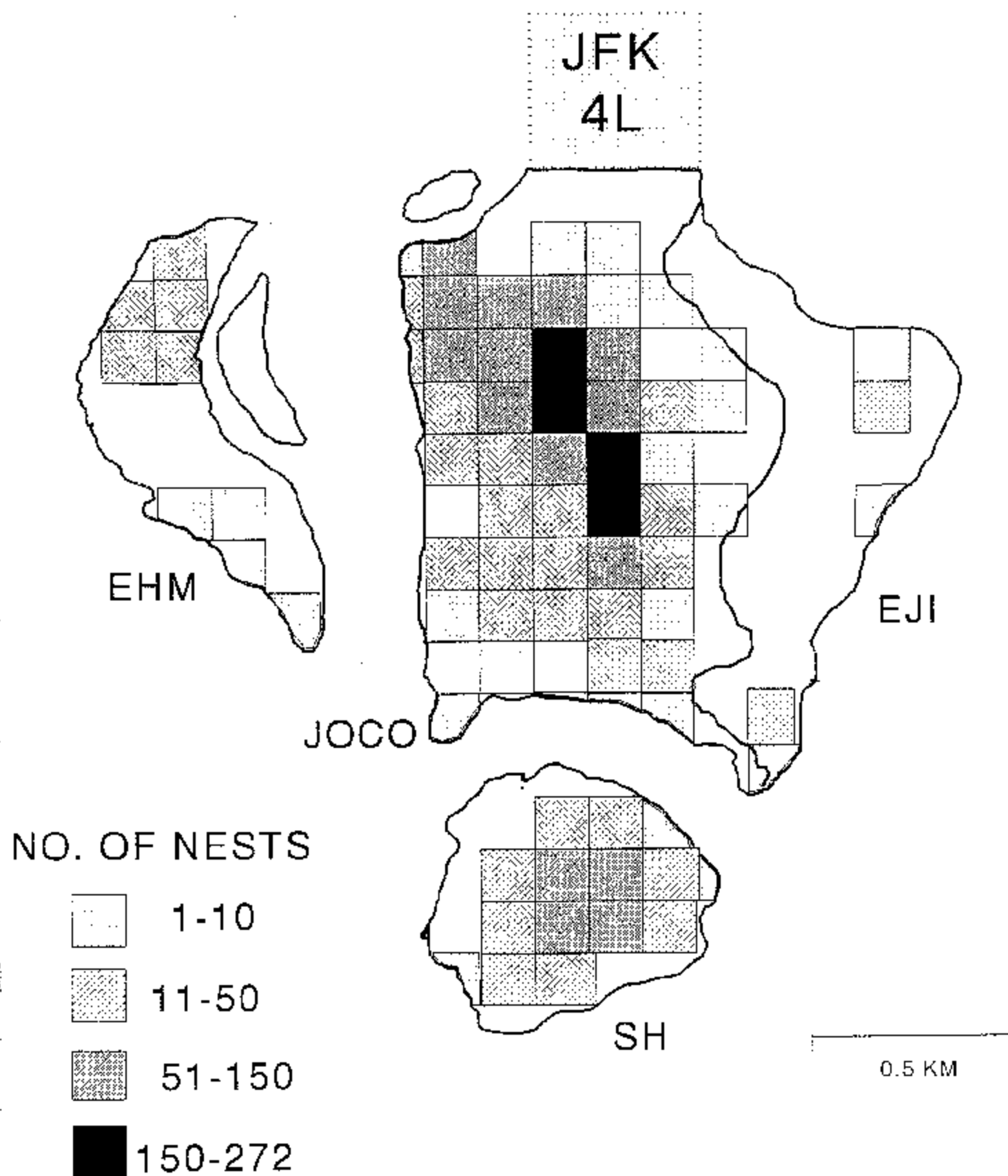
NUMBER OF GULLS SHOT AT JFKIA
1991-1997



NO. OF LAUGHING GULL NESTS, JAMAICA BAY 1990-1997

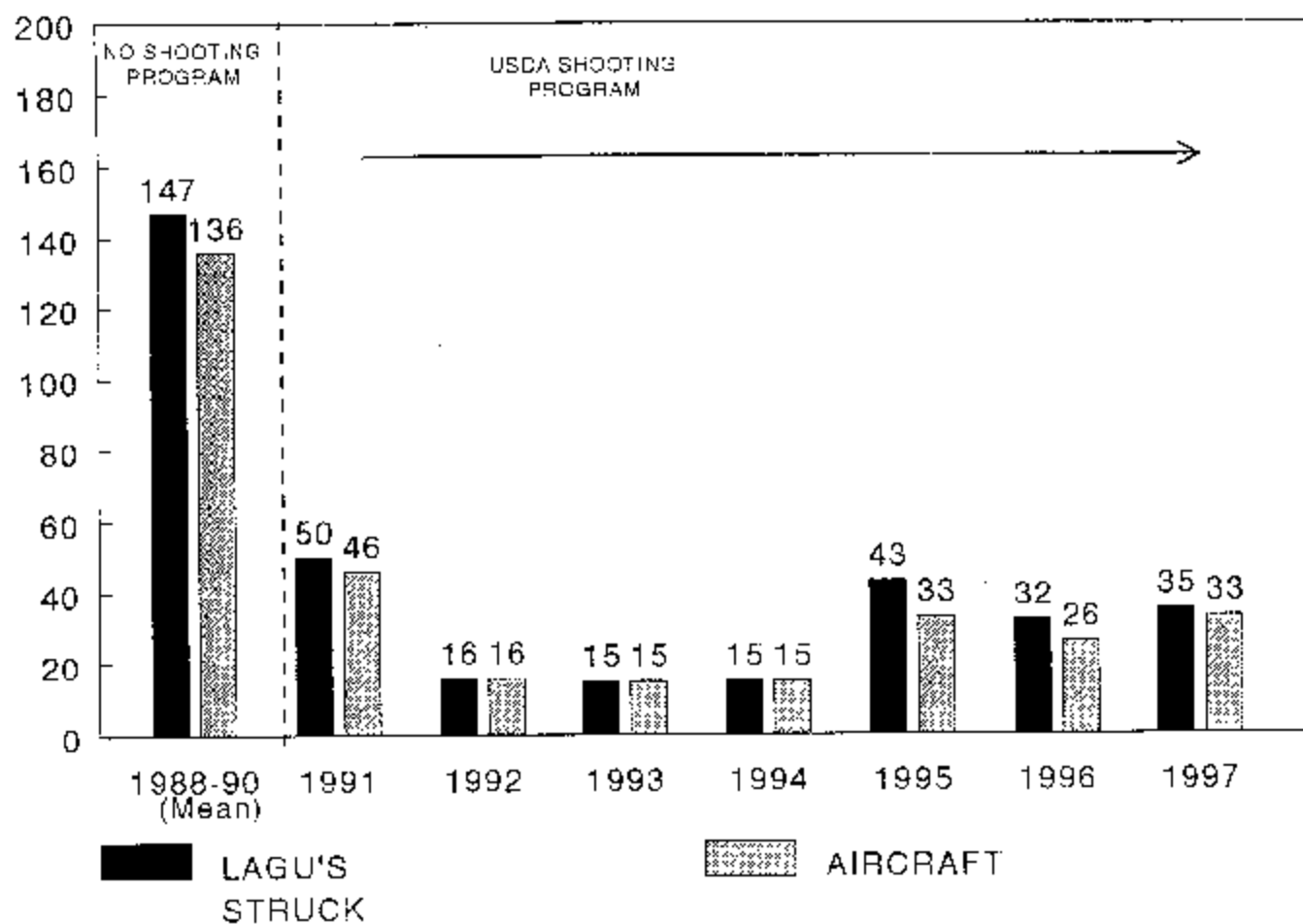
JOCO E.H. MEADOW SILVER HOLE



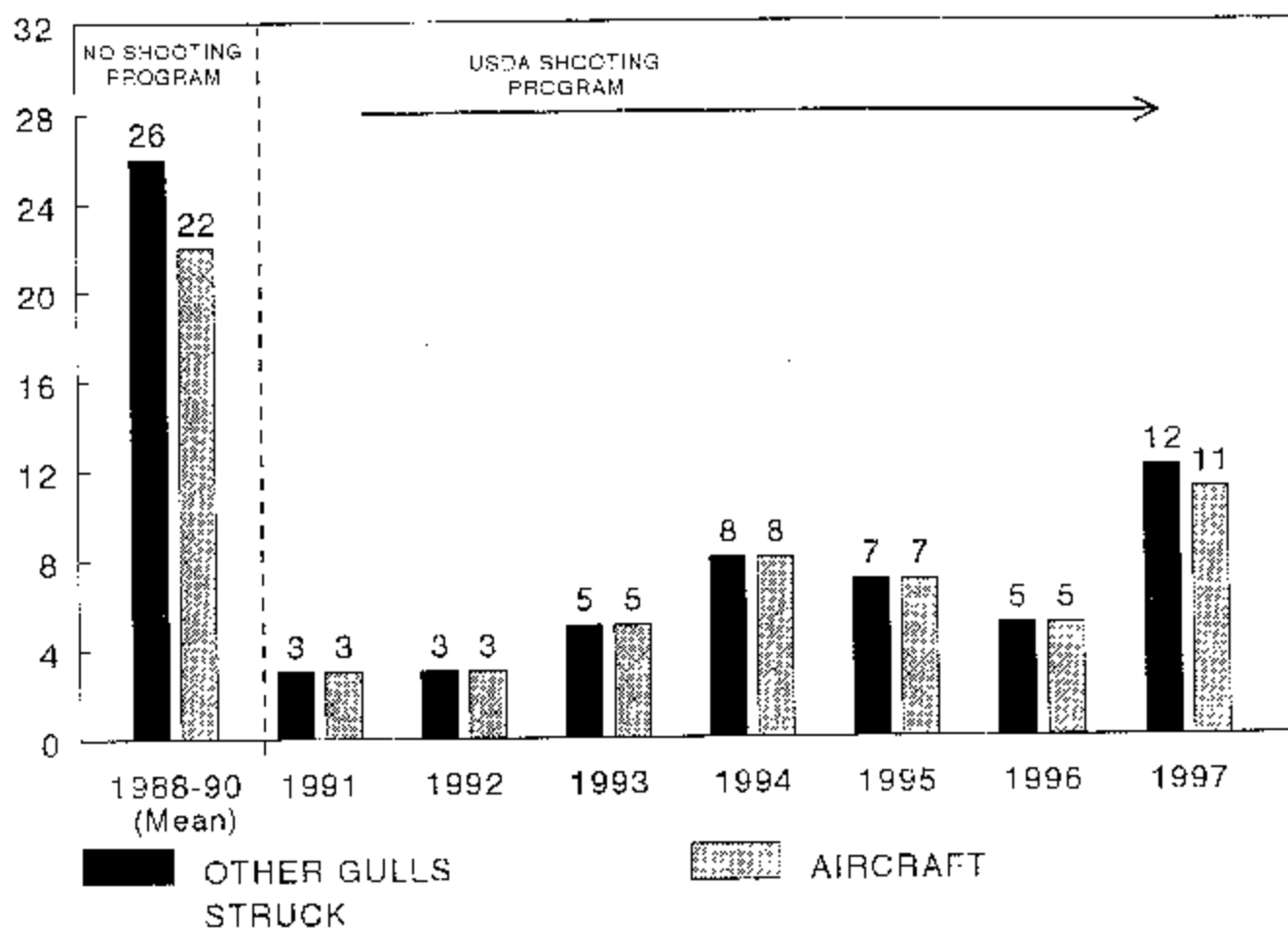


DISTRIBUTION OF LAUGHING GULL NESTS BY
1.9-HA BLOCKS, JAMAICA BAY, NEW YORK, 1997

NO. OF AIRCRAFT STRIKING LAGU'S AND NO. OF LAGU'S STRUCK, 20 MAY-15 AUGUST



NO. OF AIRCRAFT STRIKING OTHER GULLS AND NO. OF OTHER GULLS STRUCK, 20 MAY-15 AUG



APPENDIX 11

Do Canada Geese Prefer Tall or Short Grass?

Presented at 27th meeting of Bird Strike Committee Canada, 25 November 1997

DO CANADA GEESE PREFER TALL OR SHORT GRASS?

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Abstract: The use of tall grass is often recommended to keep geese and other birds from feeding and resting on airports. However, few data are available to support this recommendation for U.S. airports. We evaluated the response of Canada geese (*Branta canadensis*) to short (5.2-10.0 cm) and tall (16.1-20.3 cm) grass in a pen test in northern Ohio in 1997. There were 1.7 times more ($P = 0.02$) geese/observation in tall-grass plots (2.5 ± 0.4 ; $\bar{x} \pm SE$) compared to short-grass plots (1.5 ± 0.4) during a 10-day test with 4 captive geese in each of six 30.5 x 18.3-m pens. Bill contacts/min observed on tall-grass plots (25.2 ± 2.1) were also marginally greater ($P = 0.07$) compared to short-grass plots (15.9 ± 2.5). Mean fecal mass (g/60 m²/7 hr) collected on tall- (15.0 ± 0.7) and short-grass (15.8 ± 1.0) plots was similar ($P = 0.70$). Preference of geese for tall-grass plots over short-grass plots was strongest 1-3 days after short-grass plots were mowed. Feeding on short-grass plots increased as the grass grew longer, perhaps in response to palatability of new growth. This experiment suggests that tall grass-management at airports or other sites may not deter Canada geese from feeding or resting. We recommend additional pen and field studies to further evaluate the response of geese to various grass heights.

Key words: airport, *Branta canadensis*, Canada goose, damage, feeding, grass, habitat, repellent

INTRODUCTION

Canada goose populations, particularly populations of resident giant Canada geese, have increased dramatically in recent years. The Mississippi Flyway population increased from about 0.7 million to 1.9 million geese between 1980 and 1989 (Babcock et al. 1990). The giant Canada goose population in Ontario has recently increased two-fold every 5 years (Ankeny 1996). These burgeoning populations have resulted in numerous goose/human conflicts in agricultural, recreational (e.g., parks, golf courses), and airport settings (Hunt 1984, Kahl and Samson 1984, Conover and Chasko 1985, Conover 1988, Cleary et al. 1996, Wright 1997). For example, 24 people were killed and \$190 million in damages were incurred when an AWACS aircraft crashed at Elmendorf Air Force Base, Alaska, after striking Canada geese on take-off in September 1995.

Because large-scale killing of nuisance birds is often undesirable or impractical (Dolbeer 1986), there is considerable demand for effective nonlethal techniques to deter birds from problem sites. Numerous frightening and exclusion devices have been employed in efforts to reduce bird/human conflicts (Marsh et al. 1991, Cleary 1994), however, many are ineffective, or are cost-prohibitive (Dolbeer et al. 1995). Chemical repellents to reduce goose grazing on turf have had only short-term effectiveness (Cummings et al. 1991, 1995, Belant et al. 1996, 1997).

Another approach to reducing goose and other flocking bird numbers on airports is the use of tall grass. The general recommendation has been to maintain grass at 15-25 cm (as opposed to standard mowing which keeps grass at 5-10 cm) to interfere with visibility and ground movements for flocking birds such as gulls (*Larus* spp.) and European starlings (*Sturnus vulgaris*) (Blokpoel 1976, U. S. Department of Transportation 1993, Transport Canada 1994, U. S. Department of Agriculture 1996, Dekker and van der Zee 1996). The basis for this tall-grass recommendation has primarily come from studies in England (Brough 1971, Mead and Carter 1973, and Brough and Bridgman 1980) in which geese were not considered. To our knowledge there have been no studies to document the response of Canada geese to various grass heights although use of tall grass to discourage geese is recommended (U. S. Department of Agriculture 1996). Thus, our objective was to provide an initial evaluation of the response of Canada geese

to short and tall grass in a controlled pen experiment.

J. L. Belant provided input for pen designs. G. E. Bernhardt, S. K. Ickes, M. L. Kreithen, C. D. Levell, N. Meade, L. A. Tyson, and S. E. Wright provided field assistance. We thank Ohio Division of Wildlife personnel for providing geese for the pen test. Primary funding for this research was provided by the Federal Aviation Administration (FAA), Office of Airport Safety and Standards, Washington, D.C., and Airports Division, Airport Technology Branch, FAA Technical Center, Atlantic City International Airport, New Jersey. Procedures used involving animals were approved by the National Wildlife Research Center Animal Care and Use Committee.

METHODS

Canada geese of undetermined sex were captured during molt in northern Ohio on 20 June 1997 and transported to a 2-ha fenced pond in Erie County, Ohio. Grass and shade were available along the perimeter of the pond. Geese had primary feathers from 1 wing cut before being released into the pond. Whole-kernel corn and poultry pellets were provided as food supplements. A 0.4-ha fenced holding area adjacent to the pond was used to separate experimental from non-experimental geese. This holding area contained grass, shade, and included about 20 m² of the pond. Geese maintained in this area also were provided corn and poultry pellets.

A fenced chute connected the holding area to the test site which consisted of six 18.3- x 30.5-m pens constructed of 1.5-m high fence in a grass area. The area was oversown with perennial rye and fertilized 7 weeks before testing. Pens were spaced 5-12 m apart. A 1.5-m high heavy plastic fence was placed between adjacent pens to serve as a visual barrier. Each pen consisted of two 15.2- x 18.3-m plots (short grass and tall grass) delineated by a spray-painted line on the grass. A 0.5-m diameter pan of water was positioned in the center of each plot. A rain gauge was placed at the test site to monitor precipitation.

Grass was mowed to a height of 5 cm in all pens on 28 July. On 8 August, 24 geese were herded from the pond to the holding area and each was assigned randomly to 1 of 6 groups of 4

geese. We attached color-coded neck collars (1 color/group) to individuals in each group. For 7 days (11-15 and 18-19 August) prior to testing, the 24 neck-collared geese were herded from the holding area to the test site and the same 4 geese were placed in each of the 6 pens at 0830. The geese were herded back to the holding area at 1530. This grazing schedule allowed geese to adjust to pen conditions and establish social hierarchies prior to testing.

Three 4-m high scaffolds were positioned 16-26 m from the pens. On 18 and 19 August, geese were observed from 0900-1000 hrs from the scaffolds (see below) to determine if a side preference existed. After removing geese from pens on the afternoon of 19 August, we mowed the grass on the half of each pen (short-grass plot) that the geese did not prefer. If a preference was not shown, we randomly assigned a side to be mown. Grass was cut to a height of 5 cm and raked off the plot. The remaining half (tall-grass plot) remained uncut throughout the test. We cut the grass again in the short-grass plots after the geese were removed from the pens on the afternoon of 25 August. We measured grass height in each plot on 20, 22, 25 and 29 August with a metric ruler placed vertical to the ground at 2 random locations on each of 4 15-m transects. An observer estimated the mean and maximum length (mm) of about 10 blades of grass grasped with thumb and index finger adjacent to the ruler.

On 8 of the 10 days following 19 August (20-22, 25-29 August), geese were herded into the pens at 0830 and a person conducted observations of geese from each scaffold starting at 0900. Each person observed geese in each of 2 adjacent pens for 1 hr, alternating observations between pens every 60 sec (daily total of 30 min/pen). During each 60-sec interval, observers recorded the number of geese observed initially in each plot, and the total number of bill contacts with grass in each plot. To estimate fecal mass on each plot, we established four 1- x 15-m transects at 4.6-m intervals and collected feces daily at 1530 hr. Feces were placed in a drying room at 38 C for 48 hr before weighing. The experiment was terminated on 29 August at which time test geese had collars removed and all cut primary feathers pulled before being placed back in the holding pond. These geese were able to fly from the pond within 40 days.

Mean numbers of geese observed, mean numbers of bill contacts, and mean mass of fecal

material collected were analyzed using randomized block ANOVA with repeated measures (Statistix 1994). If main effects or interactions were significant ($P < 0.05$), we used Tukey tests to determine which means differed.

RESULTS

Grass stands in the 6 pens were in excellent condition during the test. Approximately 88 mm of rain fell from 1-19 August and 23 mm fell during the 10-day test (20-29 Aug). Tall-grass plots had a mean ($\pm$ SE) grass height of 16.1 ± 0.4 cm on Day 1 (20 Aug) of the test which increased to 20.2 ± 1.0 cm on Day 10 (29 Aug) (Fig. 1). Maximum grass height in tall grass plots ranged from 21.3 ± 0.7 cm on Day 1 to 29.1 ± 1.3 cm on Day 10. Mean grass height in short-grass plots ranged from 5.2 ± 0.1 cm on Day 1 to 10.0 ± 0.2 cm on Day 6 when grass was again cut to 5 cm height. Maximum grass height in short-grass plots ranged from 6.2 ± 0.2 cm on Day 1 to 11.8 ± 0.3 cm on Day 6.

There were 1.7 times more ($F = 8.28$; 1, 10 df; $P = 0.02$) geese/observation in tall-grass plots (2.5 ± 0.4) compared to short-grass plots (1.5 ± 0.4) during the 10-day test (Fig. 1). Bill contacts/min observed on tall-grass plots (25.2 ± 2.1) were marginally greater ($F = 4.14$; 1, 10 df; $P = 0.07$) compared to short-grass plots (15.9 ± 2.5) (Fig. 1). There was an interaction of day and plot treatment for both goose presence ($F = 5.55$; 6, 70 df; $P < 0.01$) and feeding rate ($F = 5.17$; 6, 70 df; $P < 0.01$). Preference of geese for tall-grass plots over short-grass plots was strongest 1-3 days after short-grass plots were mowed. Feeding on short-grass plots increased as the grass grew longer (Figs. 1 and 2).

Mean fecal mass ($\text{g}/60 \text{ m}^2/7 \text{ hr}$) collected on tall- (15.0 ± 0.7) and short-grass (15.8 ± 1.0) plots was similar ($F = 0.16$; 1, 10 df; $P = 0.70$). There was a day-plot treatment interaction ($F = 2.29$; 6, 70 df; $P = 0.04$) for fecal mass.

DISCUSSION

Tall grass management as a means of deterring birds from airfields or other sites is a complex action (Dekker and van der Zee 1996). The fact that no long-term studies of bird response to grass height have been done in North America makes it difficult to recommend

specific grass height ranges to deter various bird species. This experiment suggests that tall grass-management (16-20 cm) at airports or other sites may not deter Canada geese from feeding or resting. In fact, our data suggested that freshly mowed short-grass plots were avoided by geese. The increased use of short-grass plots as the grass grew was probably in response to the palatability of new growth. We recommend conducting additional pen and field studies of longer duration to further evaluate the response of geese and other North American species (e.g., gulls) to various grass heights.

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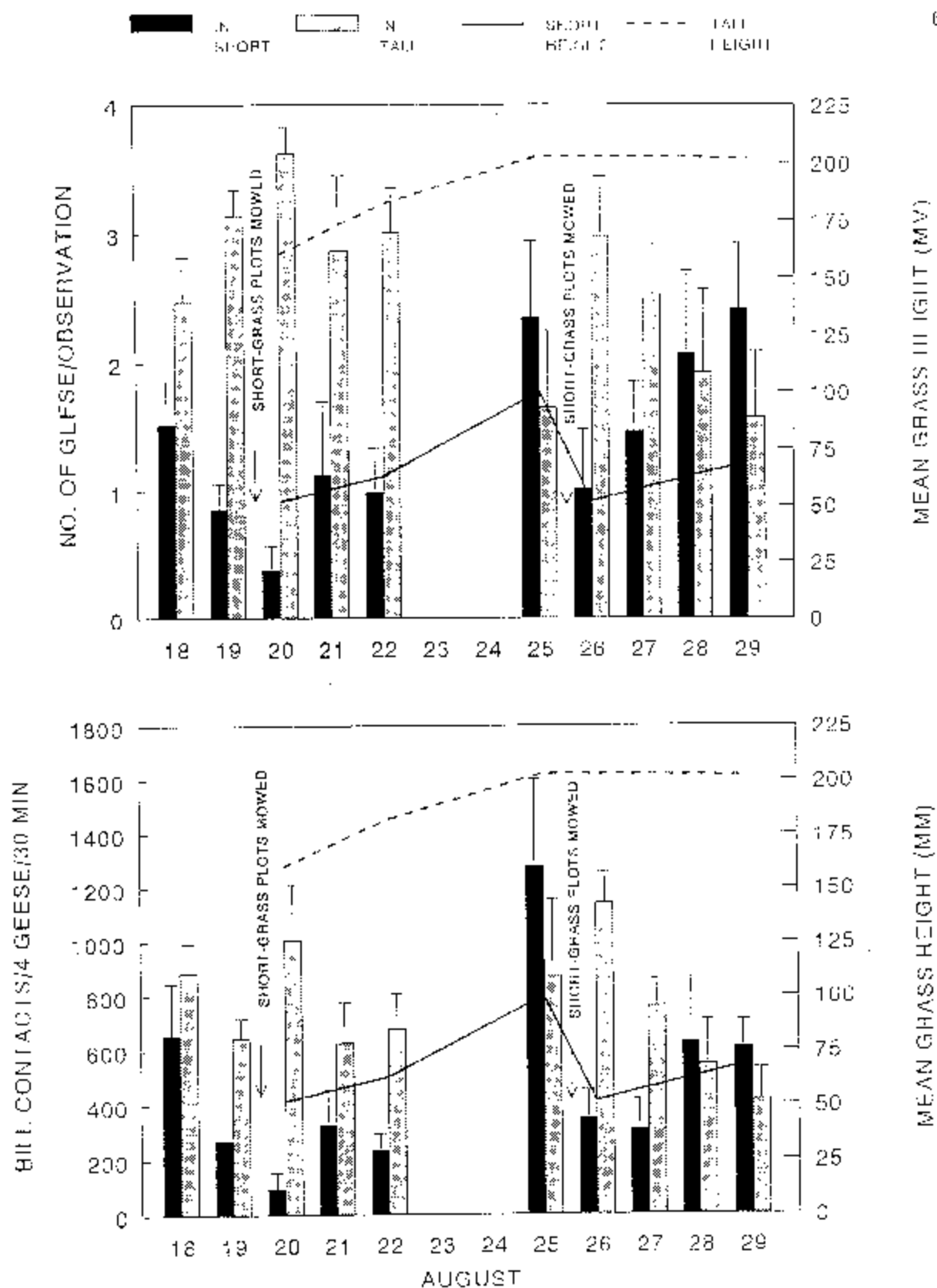


Figure 1. Mean number of Canada geese, number of bill contacts and height of grass in short- and tall-grass plots in 6 pens, Sandusky, Ohio, August 1997. Capped vertical lines represent 1 standard error.

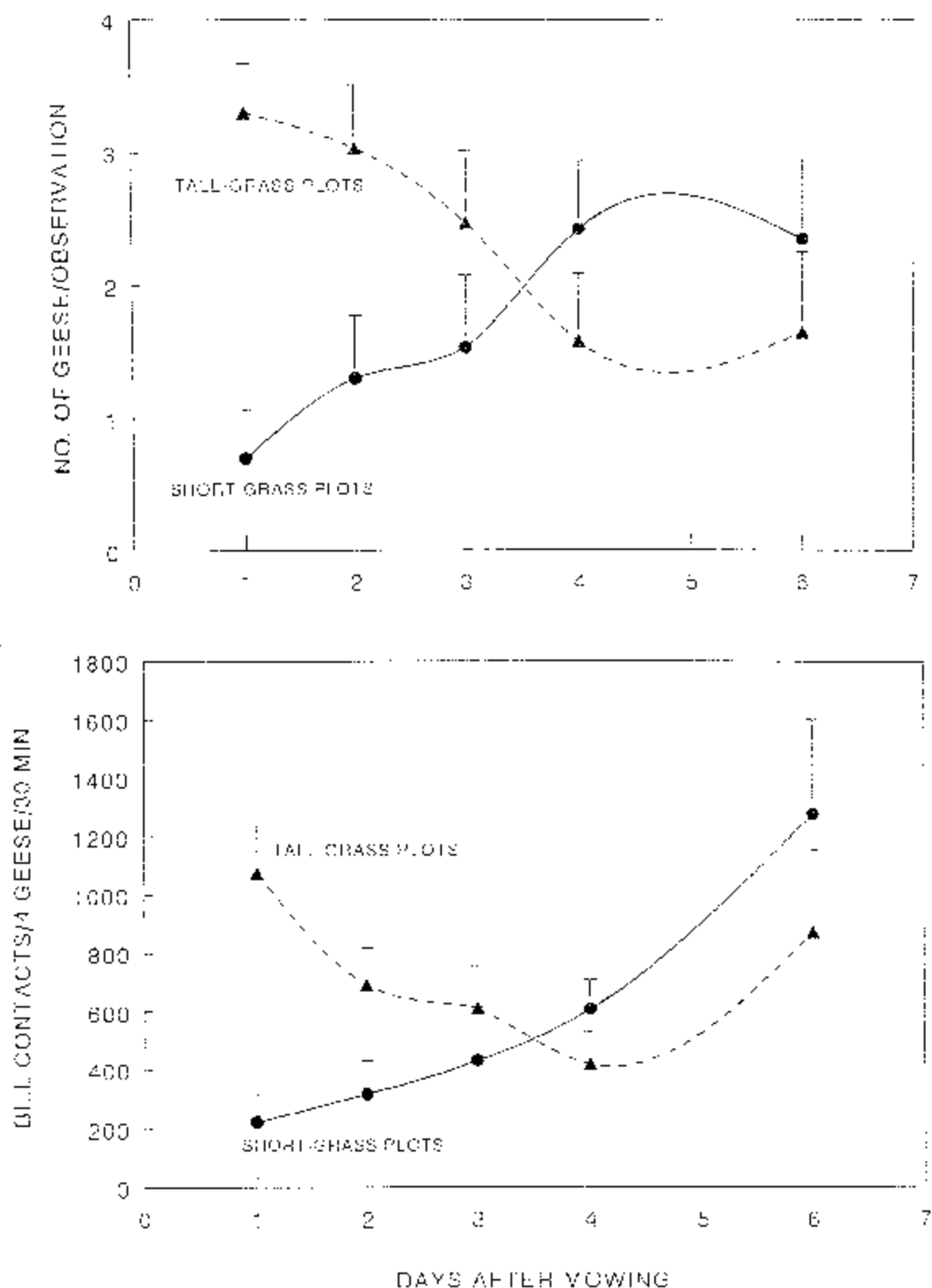


Figure 2. Mean number of Canada geese and bill contacts by geese in short- and tall-grass plots in 6 pens in relation to days after grass was mowed in short-grass plots, Sandusky, Ohio, August 1967. (See Fig. 1 for height of grass.) Capped vertical lines represent ± 1 standard error.

APPENDIX 12

The Wildlife Control Program at the Vancouver International Airport

The Wildlife Control Program at the Vancouver International Airport

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November 1996

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INTRODUCTION

The Vancouver International Airport (YVR) is the busiest commercial airport in western Canada. YVR is located on Sea Island in the Fraser Estuary - a world-class migratory bird wintering and staging area for hundreds of thousands of birds. The Fraser Estuary supports Canada's largest wintering populations of waterfowl, shorebirds, and raptors. The large number of aircraft movements and the presence of many birds near YVR pose a wide range of considerable aviation safety hazards. Until the late 1980s when a full-time Wildlife Control Program (WCP) was initiated, YVR had the highest number of bird strikes of any Canadian commercial airport (Table 1).

A new runway parallel to, and 1.7 km north of, the existing main Runway 08-26 (now Runway 08R-26L) will open in November of 1996. Not only will this runway present new wildlife control problems by virtue of its location, it will also complicate the existing WCP. For example, where it was once possible and acceptable to disperse birds to the north from Runway 08R-26L, this would now result in birds moving across the Parallel Runway (Runway 08L-26R). As a result of the expanded airside areas within which wildlife must be controlled and the greater need to control the directions in which birds are dispersed, it is necessary to revise and upgrade the Wildlife Control Program at Vancouver International Airport.

The main ways of mitigating the risks of wildlife strikes are 1) reduce the overall probability of a strike and, 2) design aircraft that can withstand a strike and experience minimal damage. Improved designs of aircraft and turbine engines have done much to reduce the damage caused by bird strikes; however, more effort is expended attempting to reduce the probability of strikes. It is reasonable to assume that worldwide, overall strike frequency is partly related to density of hazardous species around a given airport. Thus, reducing the number of animals around an airport should result in a subsequent reduction in the rate of strikes. However, due to the difficulties of obtaining accurate strike statistics, strike rates, as currently documented, are unreliable quantifiers of strike risks or the efficacy of wildlife control programs.

While there are many specific methods to reduce of the probability of wildlife strikes by reducing the numbers of animals around an airport, there are two general approaches 1) habitat management and 2) dispersal techniques. While these general approaches have been and will continue to form the basis of the WCP at YVR, it is important to understand how each of these approaches relate to each other, the biology of the animals being controlled, airport operations and many other aspects that must be considered in a wildlife control program.

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Table 1. Summary of bird strike data for Vancouver International Airport, 1977 to 1995.

Year	No. of Bird Strikes	No. of Aircraft Movements (x 1000)	Bird Control Program	Strikes/10,000 Movements
1977	58	236	A	2.5
1978	50	248	A	2.0
1979	46	273	A	1.7
1980	58	268	A	2.2
1981	75	263	A	2.9
1982	33	228	A	1.4
1983	55	223	A	2.5
1984	49	219	A	2.2
1985	46	235	A	2.0
1986	57	278	A	2.1
1987	50	302	B	1.7
1988	30	325	C	0.9
1989	26	325	C	0.8
1990	23	317	C	0.7
1991	54	288	C	1.9
1992	36	290	C	1.2
1993	34	289	C	1.2
1994	108	301	C	3.6
1995	98	311	C	3.2

A = Airport Personnel

B = Private Consultant

C = Corps of Commissionaires

The Wildlife Control Program at YVR

Habitat management to make the airport environs less attractive or unavailable to hazardous wildlife is the most effective long-term method of reducing strikes. Because no matter what habitat types exist at YVR (e.g., forest, oldfield, mowed grass, saltmarsh, etc.), the diverse avian community found on and near Sea Island contains species that will be attracted to those habitat types. Thus habitat must be manipulated so that the numbers of the most hazardous species are minimized.

The second method of strike reduction is to disperse birds occurring in the vicinity of the airport. This type of control includes pyrotechnic "scare" devices, distress calls and other acoustic deterrents, "dummy" wildlife (e.g., owls, dead crows) and other visual deterrents, falconry, trapping and translocating, prey eradication (i.e., trapping, repelling, poisoning), and the killing of problem animals. Alone or in combination, these methods are designed to reduce the numbers of hazardous wildlife in the airport area.

OBJECTIVES OF THE WILDLIFE CONTROL PROGRAM AT YVR

The overall goal of the WCP at YVR is to prevent collisions between wildlife and aircraft. This goal is not likely to ever be completely met on a long-term basis; therefore, a more realistic goal is to minimize wildlife-aircraft collisions that are likely to cause damage to the aircraft and thus cause an air-safety concern. In order to achieve this goal, a number of objectives must be set for the WCP. These include:

- minimize the number of individuals of hazardous wildlife species in the airport environs;
- modify the distribution and movements of hazardous species by altering land uses and other factors that contribute to unsafe situations;
- actively disperse problem birds in a safe and effective manner;
- inform pilots, through the tower, of potentially hazardous wildlife distributions and movements until they can be remedied; and
- monitor the success of the WCP in order to objectively evaluate the program and to make necessary improvements to meet the overall goal.

It is the purpose of this report to develop a WCP plan that meets these objectives.

EVALUATION OF EXISTING WILDLIFE CONTROL PROGRAM

It is not the purpose of this report to suggest changes to the existing WCP where current methods are effective in achieving their objectives and will continue to be effective when the Parallel Runway becomes operational. In order to determine the existing effectiveness of the WCP, a brief review of the current practices is required. It is not our intention to conduct a thorough audit of the WCP as this has already been conducted under contract to YVRAA. Our comments are based on our studies of birds carried out at YVR during the previous 6 years and the professional judgment of the authors.

In general, priorities of the current WCP approximate what they should be given the risk of damage caused by the various groups of birds (see next section). However, there are a few exceptions. For example, wildlife controllers generally ignore perched, yet actively hunting, raptors. While this is understandable given the large area the controllers need to cover and their "search image" for flocks of birds; raptors, nevertheless, are seldom actively controlled.

A second deficiency is more significant. Until March 1996, wildlife control activities ended in the early evening hours during winter and before dark during summer. As a result, birds that used the airfield were not actively controlled at night. That pattern of control reinforced nocturnal feeding behaviour and resulted in large numbers of birds loafing near the airport by day then moving onto the airport near dark. The major species of concern are ducks and owls with some concern for geese and shorebirds (primarily dunlin).

Habitat Management

Airside Habitats

Grass and Standing Water

At YVR, current management goals specify grass heights of 10-25 cm. In theory, grass heights above 10 cm are intended to discourage flocking birds, while grass heights below 25 cm are intended to discourage raptors. Not only are these grass heights not always possible to maintain, but the suitability of these heights in deterring birds is questionable. Observations on the present use of these mowed habitats by birds indicate that the management plan regarding grass height is not achieving its goals. Large numbers of waterfowl, gulls, shorebirds, and starlings occur regularly at many airside locations. Further, raptors continue to hunt and rest at airside locations.

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The failure to meet management goals regarding grass heights appears to stem from several factors. First, the standing height of grass at many locations is actually much less than 10 cm. Grass that is shorter than 10 cm results because mower blades are not adjusted to actually leave a minimum grass height of 10 cm; limitations due to soil moisture (both excessive or wanting) at many locations precludes the establishment of standing grass in the 10-25-cm range; and the species of grass that grow in the airfield are not conducive to maintaining a stiff, upright sward. As a result, grass in the airfield is easily trampled down into a dense thatch by gulls and waterfowl. Secondly, standing water accumulates on the airfield at many locations during the winter. This standing water attracts many birds that further contributes to trampling, grazing and otherwise destroying the grass canopy. Efforts to correct the standing water problem are currently underway. However, in the short-term these efforts have contributed to the bird control problem by providing exposed soil for feeding birds and generally have only succeeded in moving the accumulations of water around, not in eliminating them. It remains to be seen whether or not the efforts to eliminate standing water on the airfield will be successful in the long term.

Drainage ditches and the accumulation of standing water in the airside zone during winter rains have long been recognized to be major contributors to bird hazards at YVR. Although there has been a proposal to enclose the ditches, no action has been taken in this regard.

Earth Worm Control

YVRAA is currently considering use of Teraclor, a fungicide that might control earthworm populations in turf grass areas. By eliminating or significantly reducing earthworms, Teraclor could indirectly reduce the numbers of dabbling ducks, shorebirds, gulls and European starlings that forage in the airside zone during winter rains. The effectiveness of this chemical will be evaluated in experimental trials during the fall of 1996. If successful, full-scale application of Teraclor along Runway 08R-26L will follow.

Buildings

Many buildings in the airside zone provide attractive roosting and nesting habitat for several hazardous species of birds. The 1995 Wildlife Control Plan calls for the regular inspection and removal of these nests and the removal of problem birds. Building inspection and nest elimination is generally done on an annual basis by the wildlife controllers. However, many buildings are still used intensively by barn owls, swallows, starlings, and rock doves. For example, the storage shed to the southeast of the Air Canada hangar (adjacent to Runway 08R-26L) is used by hundreds of starlings during the

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spring/summer nesting period. Therefore, while many nests and birds may be removed from airport buildings, the large number of structures at the airport and their great accessibility to birds results in considerable use by birds despite the efforts of the wildlife controllers.

Evidence from recent barn owl strikes at YVR suggests that most involved newly fledged birds from airside nesting sites. Barn owls tend to remain near their natal sites for several weeks to several months after fledging, and young birds may be more susceptible than adults to collisions with aircraft. There exists a great need not only to remove nesting and roosting birds, but to modify these structures to prevent their use in the first place.

Groundside Habitats

Habitats adjacent to the airside zone attract many species of birds that can pose hazards to air-traffic safety. As a result, it is necessary for YVRAA to have some control over the land uses that occur in the vicinity of YVR. Transport Canada's *Guidelines for Land Use in the Vicinity of Airports* (TP1247E) contains information on land uses that are not compatible with the operation of a safe aerodrome. Research by LGL Limited during 1994-95 identified several land uses with the potential to threaten air-traffic safety at YVR. These uses are summarized below.

Mowing/haying/grazing

Expansive patches of mowed, hayed, and grazed grass at groundside locations of northeastern and central Sea Island attract hundreds of Canada geese, dabbling ducks, gulls, and European starlings during winter. These birds use mowed grass areas for foraging and loafing. The attraction varies among species, but is greatest during and following winter rains because local bird numbers are high and surface water accumulation forces soil invertebrates (upon which the birds feed) to the surface. Open fields with short grass also improve the birds' ability to detect predators; thereby offering them much-needed security.

If these short-grass situations are not eliminated, then the normal movements of these birds and the movements resulting from frequent disturbances by people and dogs are expected to pose high risks to aircraft using the Parallel Runway. Short of fencing these areas, controlling public access will not be easy because there is a long history of recreational use there.

The Sea Island Conservation Area (SICA)

SICA is an area of 140 ha along the north side of Sea Island. SICA was established in partial compensation for wildlife habitat lost through the

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development of the Parallel Runway Project, and is presently managed by the Canadian Wildlife Service (CWS). SICA is used primarily by raptors, great blue herons, ring-necked pheasants and small passerines. Many birds that use SICA tend to remain there due to the high suitability of the habitat. However, SICA also receives intensive use by people that walk their dogs there. Since SICA was established, there has been a gradual change from people restricting their activities to the dykes (because the lands inside the dykes were clearly being farmed) to more widespread use of the tall grass fields because they appear "vacant" and are known to be public lands. The presence of people and unleashed dogs in the fields have important implications for air-traffic safety. People, and especially dogs, routinely flush birds from the ground or from perch sites within SICA. Not only do such actions compromise the value of SICA as a conservation area, but the tendency of some birds flushed from SICA to fly toward the Parallel Runway will jeopardize air-traffic safety when the Parallel Runway becomes operational.

The Greater Vancouver Regional District (GVRD) landfill - Iona Island

The GVRD "grit"¹ landfill on Iona Island creates air-traffic safety problems by attracting and supporting increased local populations of gulls, northwestern crows, rock doves, European starlings, and other birds that forage on the "grit". The attraction of these birds to the vicinity of the airport increases the risk of strikes involving these species.

Active Control

Pyrotechnics and Lethal Control

The WCP at YVR relies heavily on pyrotechnic devices (i.e., cracker shells, screamers, bangers, etc.) to disperse birds from problem areas. Although these devices can be very effective, improper or excessive use can limit their effectiveness because the birds gradually learn that they are not much of a threat. The effectiveness of these pyrotechnics is further reduced when the harassment is not sustained. Simply disturbing birds at one location and allowing them to settle at a nearby location (where they may not pose a direct hazard), will likely reduce the amount of time between the initial dispersal and their return.

European starlings, rock doves, gulls and northwestern crows are sometimes controlled by killing one or more individuals with live ammunition. To the best of our ability to assess the use of lethal control, it appears that gulls are

¹ "Grit" contains foods such as seeds and others that are not degraded by the primary sewage treatment process.

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primarily killed to reinforce the pyrotechnics. European starlings are killed in considerable numbers to reduce the size of the flocks frequenting the airfields and rock doves are both live-trapped and killed near buildings. Live ammunition is an effective method of reinforcing the effectiveness of pyrotechnics and should be used in that role.

Mammals are mainly live-trapped and removed from the airport with the exception of rats which are killed.

Human Disturbance

As a result of harassment by the wildlife controllers, many birds using airside areas have become accustomed to the WCP. Thus, many birds react to the presence of the wildlife controller's truck by flushing long before the controllers are within shooting distance. These birds are recorded as having been controlled by "vehicle presence" or, if the wildlife controller pursued the flock in his vehicle, controlled by "chase". While it is better to allow birds to react to the vehicle than to shoot at them while out of range with pyrotechnics, the control established by this method is short-lasting because just as the WCP truck triggers a response in birds to flush, as soon as the truck departs, the birds quickly return to their airside feeding areas.

Distress Calls

Distress calls are used infrequently during the normal course of wildlife control operations. During six winters of biweekly surveys at the airport, no distress calls were heard by survey personnel. While limited use of distress calls is recommended in order to ensure that they remain effective, it appears that the current WCP makes little or no use of this technique.

Sirens

The use of sirens by the current WCP is also very limited. As with distress calls, no sirens were heard by bird survey personnel working at the airport during six recent winters. Sirens are relatively ineffective at dispersing birds, which may explain their limited use by wildlife controllers at YVR.

Phoenix Wailers

At present, there are two Phoenix Wailers operating near the ends of runways 08R-26L and 12-30. Two more Wailers are expected to be installed near the Parallel Runway. The manufacturer of these devices reports that they work by creating a zone that is acoustically uncomfortable for wildlife, thereby keeping them away from that area. Independent research into the effectiveness of these devices at airports is inconclusive.

Although current research does not support the conclusion that Phoenix Wailers are effective deterrents for birds, the degree and rigour of testing is not adequate to dismiss their use entirely. Wildlife controllers at YVR indicated that, according to their anecdotal observations, the wailers are effective especially for shorebirds and short-eared owls. However, the observational data collected were inappropriate to reach this conclusion. If Phoenix Wailers are being relied on for supplemental bird control during the day, and primary control at night, their effectiveness needs to be determined. Rigorous testing is required before wailers are relied on for any measure of bird control at YVR.

Decoys

Extremely limited use of owl, hawk, or gull decoys is reported by the wildlife controllers

Perching Deterrents

Some perch sites for gulls and other species are treated with a repellent called Hotfoot. Hotfoot contains a chemical that irritates the feet of birds and thereby discourages them from perching on the treated object. Another perching repellent called Nix-a-lite is used to a limited extent on the roofs of some buildings. Nix-a-lite resembles sharp spikes that discourage birds from perching because of the discomfort it causes. However the high cost of the material prevents more extensive use.

Reporting

Wildlife controllers currently keep a log of kilometres driven, numbers of birds controlled, and the type of control used. These data are summarized in monthly reports which also include recommendations and incident reports. The monthly totals are then combined into an annual report that summarizes the year's recommendations, actions and incidents. There are some limitations to the current reporting procedures. For example, it would be useful to know if there are annual changes in the methods of control used (e.g., was more use made of distress calls this year than last year rather than relative to other methods as is currently reported). The number of times groups of animals are controlled as well as the number of individuals controlled is important to record and summarize. This will present valuable information on the amount of control required and the average size of the flocks controlled. Perhaps the largest omission in the current data recording process is that no information is kept on bird numbers and distributions adjacent to the airport. These birds may not be directly controlled, and

therefore, do not get counted. Also, although the location of control activities is well known by staff, there is no rigorous reporting of this information.

PRIORITIES FOR WILDLIFE CONTROL

Species

There are often more birds present on the airport than can be dealt with at one time. Therefore, it is important that priorities are established to focus control efforts on those species that present the greatest hazard to aircraft safety. Currently, "target" species include gulls, European starlings, sandpipers, dunlin, crows, ducks, snow geese, Canada geese, great blue herons, hawks, eagles and owls. This list includes the overwhelming majority of birds on the airport; therefore, it is not particularly helpful in setting priorities for bird control.

Priorities should be determined by risk of damage to aircraft rather than simply by frequency of strikes or a subjective impression of hazards to aircraft. Table 2 summarizes the rate of damaging strikes by bird groups from worldwide statistics and presents the average annual strike rate at YVR for these same groups of birds. By multiplying these figures together and ranking the results, a clearer picture of the types of birds that present the greatest risk of causing damage to aircraft at YVR emerges. Priorities should be assigned as follows:

1. gulls
2. shorebirds
3. dabbling ducks and geese (waterfowl)
4. hawks, eagles and falcons (diurnal raptors)
5. European starlings and crows
6. owls
7. great blue herons

Because of the methods now used to report control activities (i.e., numbers of birds controlled rather than the number of times control was required), it is difficult to assess where priorities have been placed in the current WCP. European starlings are the primary species controlled in terms of overall numbers, followed generally by snow geese, dunlin and gulls. Swallows, crows, ducks and Canada geese are generally next in terms of numbers controlled, followed by herons, hawks and sandpipers.

Table 2. Strike and damage ratings based on 1989-1993 IBIS* bird strike statistics and 1984-1988 and 1991-1995 YVR bird strike statistics.

	IBIS Strike Statistics			Average Annual Strikes at YVR	IBIS Damage Rate * YVR Strike Rate*100	Damage and Strike Ranking
	Total Strikes	Strikes with Damage	Percent Damaging Strikes			
Gulls	3257	282	9%	7.7	67	1
Passerines	3599	72	2%	10.5	21	5
Raptors	1341	263	20%	1.9	37	4
Plovers	750	76	10%	0.2	2	9
Doves	687	79	11%	0.1	1	10
Waterfowl	340	38	11%	4.4	49	3
Shorebirds	219	19	9%	5.9	51	2
Hérons etc.	267	40	15%	0.2	3	7
Owls	167	16	10%	2.2	21	5
Upland Game Birds	101	34	34%	0.1	3	7
Cranes, Rails, Coots	31	4	13%	0.1	1	10
Unidentified	12100	925	8%	20.7	158	--

*IBIS is the International Bird Strike data base maintained by ICAO (International Civil Aviation Organization)

Habitats

It is important to recognize that bird hazards to aircraft at YVR result from the combined effects of many variables. At a local scale, the distribution of habitat types and the arrival and departure paths of aircraft have the largest effects on these hazards. Presently, many of the hazards that birds pose to aircraft using YVR can be related to specific habitat conditions. The locations of the habitats referred to below are depicted in Figure 1.

Airside Habitats

The airside zone is dominated by mowed-grass habitat, with lesser amounts of pavement, buildings, and ditches. In addition, many groundside locations on Sea Island are also mowed. Mowed grass habitat is highly attractive to virtually all of the hazardous species at YVR (Table 3). The attraction intensifies when water ponds in the fields following winter rains. Paved runway surfaces and ditches near much of the mowed-grass habitat also offer feeding/loafing opportunities to several species.

Table 3. Location of hazards created by species that use mowed-grass and other airside habitats.

Species	Main Locations of Hazard
Great blue heron	western and northern Sea Island
Canada goose	all airside locations; particularly the northern two-thirds of Sea Island
Snow goose	the extreme western portion of Sea Island
Dabbling ducks	all airside locations; particularly the western half of Sea Island
Bald eagle	all mowed-grass locations
Northern harrier	all mowed-grass locations; particularly western and northern Sea Island
Red-tailed hawk	northern and western airside locations
Rough-legged hawk	northern and western airside locations
Shorebirds (dunlin)	western airside locations
Gulls	all airside locations
Barn owl	all airside locations
Northwestern crow	all airside locations; particularly northern and western ones
European starling	all airside locations

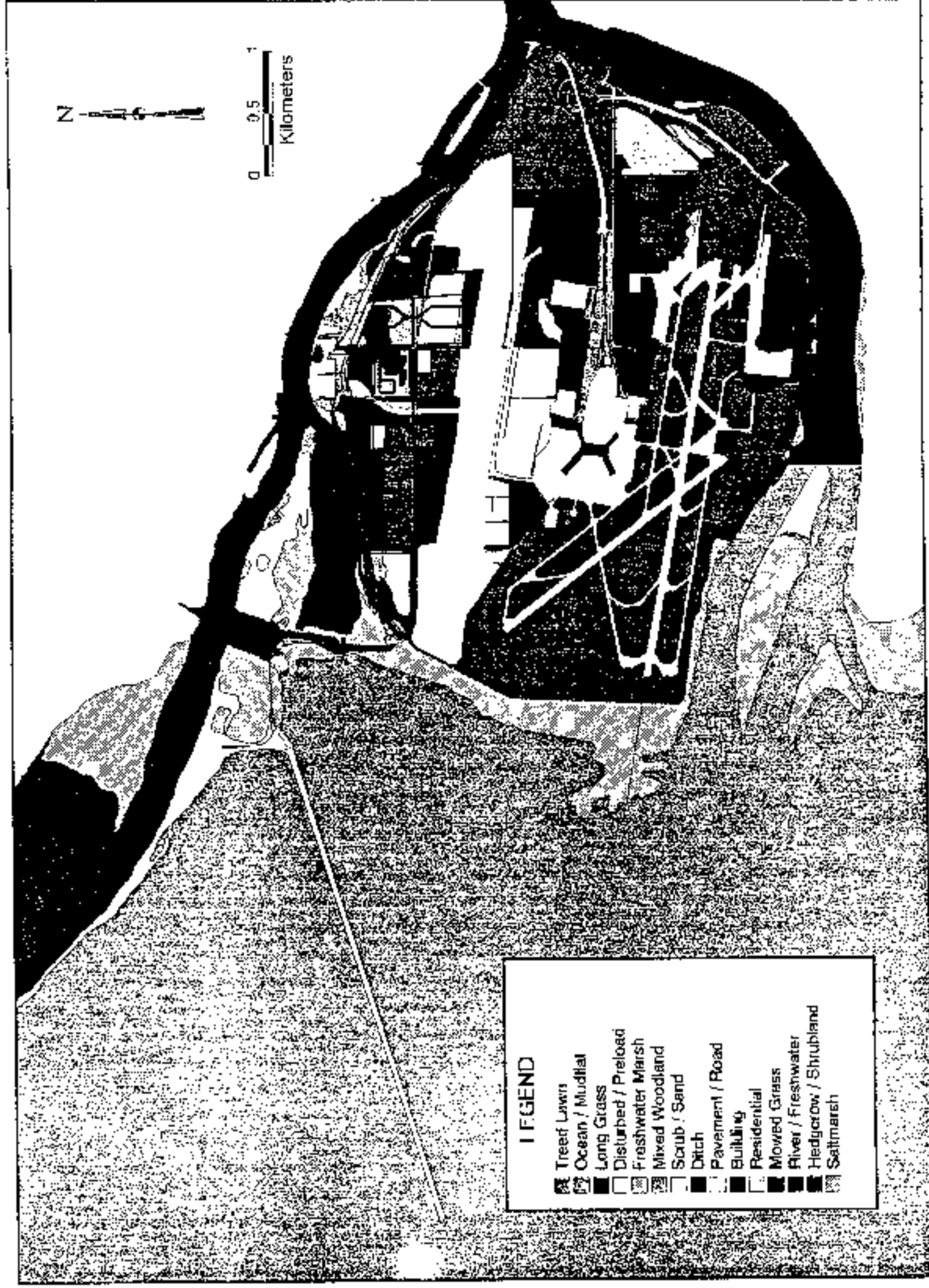


Figure 1. Major habitats of Sea Island.

Saltmarsh Habitat

The saltmarsh habitat that surrounds the western portion of Sea Island attracts significant numbers of birds (Table 4). The proximity of the saltmarsh to aircraft flight paths results in many birds being present below approach/departure paths or flying through aircraft flight paths as they move to and from this habitat type.

Table 4. Location of hazards created by species that use saltmarsh habitat.

Species	Main Locations of Hazards
Great blue heron	western and southern Sea Island
Canada goose	western and southern Sea Island
Snow goose	western Sea Island
Dabbling ducks	western and southern Sea Island
Bald eagle	western and southern Sea Island
Northern harrier	western and southern Sea Island

Aquatic Habitats

Other habitat types that attract numerous birds are the ocean and its exposed foreshore mudflats and river habitats (Table 5). The extent of the presence of these habitats depends largely on tide height. Although birds actually using these habitats are not within any aircraft flight paths (except some birds that fly over this habitat), the proximity of these habitats to some flight paths results in many birds moving through aircraft flight paths as the birds fly to, from, or over these habitats. The dawn and dusk flights of gulls along the Middle Arm of the Fraser River pose significant hazards to aircraft approaching runways 26L and 30, or departing on runways 08R and 12 at those same times.

Table 5. Location of hazards created by species that use ocean/mudflat and river habitats.

Species	Main Locations of Hazards
Great blue heron	western and southern Sea Island
Dabbling ducks	western and southern Sea Island
Bald eagle	western and southwestern Sea Island
Shorebirds (dunlin)	western and southwestern Sea Island
Gulls	western and southern Sea Island
Northwestern crow	western and southern Sea Island

Parallel Runway

The Parallel Runway habitats will resemble the current airside habitats described above. The major exception arises from the fact that the Parallel Runway is slightly elevated above the surrounding landscape and the field surfaces have been sloped to prevent the accumulation of surface water. Pavement and ditches will adjoin most of the grass areas. Airside buildings will eventually be constructed along the northern perimeter of the Parallel Runway.

ANALYSIS OF HAZARDOUS SPECIES

The need for wildlife control around airports is a result of the hazards and risks posed by the species that occur near them. The degree to which any species or group of birds pose hazards to aircraft depends on many factors that affect the probability that an aircraft will collide with a bird or flock of birds. In addition to structural features of aircraft, many hazards and risks result from specific attributes of the ecology of the species/group in question. Ecological factors that affect both hazards and risks that birds pose to aircraft include:

- Presence: does the species/group occur near the airport?
- Abundance: how many individuals typically occur at/near the airport, and when?
- Size: what is the relative body size of an individual?
- Flocking: what is the typical number of individuals flying in a flock? What is the typical flock configuration or density?
- Flight behaviour: does the species/group fly through aircraft taxiways or approach/departure paths?
- Predictability: the degree to which the movements of a species/group occur in repeated fashion regarding timing and location.
- Habitat use: for what purposes do the birds use specific habitats whereby they pose hazards?
- Habituation: the degree to which the species/group adapts to the presence of aircraft or dispersal techniques.

Although upwards of 300 species of birds could occur near YVR, evidence from bird strike data indicate that significant hazards (i.e., those requiring mitigation) result from only some of those species. Information regarding these species is presented in Table 6.

Information in Table 6 describes the population and habitat conditions that existed during 1994-1996. Predictions of future conditions need to account for the addition of the Parallel Runway and related facilities.

Table 6. Analysis of hazardous birds at YVR.

Group/Species	Maximum Abundance near YVR	Relative Bird Size	Typical Flock Size	Typical Flight Behaviour and Heights (AGL)	Predictability	Habitat Use	Habitation	Mitigation
Great blue heron	up to 100; fairly constant all year	very large	1	Extensive N-S movements over western Sea Island in spring and summer; E-W movements over northern Sea Island in winter. 1-80 m AGL.	Very predictable during breeding season; moderately predictable during the rest of the year	Flies past western Sea Island during foraging trips between Pacific Spirit Park and Fraser Delta during breeding season; uses northern Sea Island extensively during the winter to hunt for voles.	Appears to tolerate aircraft, but does not appear to habituate to non-lethal, active dispersal.	Use pyrotechnics to disperse birds from problem areas.
Canada goose	up to 1000; fairly constant all year; reduced flight activity during the spring and summer (breeding and moulting season).	very large	2-30	Extensive flights over northern and eastern Sea Island. 5-30 m AGL.	Constant inland flight activity during daylight hours in the winter; unpredictable flights during the rest of the year.	Flies to areas of short grass and plowed/disturbed soil to feed and loaf during the day. Roosts and loafs in nearby aquatic habitats.	Appears to be very tolerant of aircraft and non-control disturbances by humans, but does not appear to habituate to non-lethal, active dispersal.	Eliminate mowed grass habitats where possible (i.e., grow long grass); reduce uncontrolled disturbances by people and dogs; use pyrotechnics to move flocks from problem areas.
Snow goose	up to 3000; present in fluctuating numbers from October through April	large	5-1000	Extensive flights over the foreshore of western Sea Island. 10-100 AGL.	Unpredictable flight activity during day and night; highly susceptible to disturbance by bald eagles.	Feeds on sedges in the saltmarsh habitat; will fly inland short distances to graze in mowed-grass habitats.	Appears to be very tolerant of aircraft and non-control disturbances by humans, but does not appear to habituate to non-lethal, active dispersal.	Should not be tolerated along the foreshore of Sea Island; move using pyrotechnics and lethal control where required.
Dabbling duck, including primarily: American wigeon, mallard, northern pintail and green-winged teal	up to 15,000; very few during mid spring to late summer; very abundant throughout fall, winter, and early spring.	medium	2-100	Extensive flights over river, ocean, and saltmarsh habitats; extensive flights over all of Sea Island during winter months. 1-30 m AGL.	Relatively constant flight activity during day; dusk and dawn peaks in activity. Some nocturnal flight activity.	All aquatic habitats (including ditches) offer foraging and loafing opportunities; during winter months extensive foraging is done in mowed grass habitats for grass (by American wigeon) and soil-borne invertebrates (by mallards).	Appear to be very tolerant of aircraft and non-control disturbances by humans. Appear to habituate to non-lethal, active dispersal.	Eliminate mowed-grass habitats where possible (i.e., grow long grass); reduce uncontrolled disturbances by people and dogs; use pyrotechnics in a sustained fashion and lethal control to move flocks from problem areas.
Bald eagle	up to 20; few during fall, rising gradually to a peak during late winter/early spring	very large	1-2	Generally flies in N-S direction over western Sea Island and the foreshore; 5-100 m AGL. Some soaring up to 300m over northern Sea Island on sunny days.	Unpredictable flight behaviour; flies sporadically throughout the daylight hours.	Hunts waterfowl and scavenges prey at many aquatic and terrestrial locations; thermals over northern Sea Island provide soaring habitat.	Appear to be very tolerant of aircraft and moderately tolerant of non-control disturbances by humans. Does not appear to habituate to non-lethal, active dispersal.	Discourage prey species through habitat modification and active dispersal; use pyrotechnics to control eagles in problem areas; eliminate perching opportunities in problem areas.

Table 6. Analysis of hazardous birds at YVR.

Group/Species	Maximum Abundance near YVR	Relative Bird Size	Typical Flock Size	Typical Flight Behaviour and Heights (AGL)	Predictability	Habitat Use	Habituation	Mitigation
Northern harrier	up to 30; very few during late spring to late fall; relatively constant during the remainder of year.	medium-small	1	Flies mostly over vegetated habitats that support voles. 2-20 m AGL.	Relatively constant flight activity during daylight hours.	Seeks habitats that support voles (e.g., saltmarsh, grass fields, mixed woodland)	Appears to be moderately tolerant of flying aircraft. While perched, does not appear to habituate to approaches by humans; while flying, will approach humans within a few meters; it does not exhibit a strong response to unsustained, active dispersal.	Harass with pyrotechnics in a sustained fashion near the runways.
Red-tailed hawk	up to 50; fewer during spring to mid fall; relatively abundant from mid fall to early spring.	medium	1	Spends little time actively flying. Soars during sunny days. 10-150 m AGL.	Unpredictable flight behaviour; soars sporadically over northern Sea Island during sunny days.	Attracted to habitats with voles and perches >2 m high (e.g., SICA).	Appears to be very tolerant of flying aircraft. Does not appear to habituate to approaches by humans; however, does not exhibit a strong response to unsustained, active dispersal.	Use pyrotechnics in a sustained fashion to control birds in problem areas; eliminate perching opportunities in problem areas. Problem birds may require trapping and relocation (see text).
Rough-legged hawk	up to 15; absent from late spring to mid fall; fluctuating numbers during the remainder of the year.	medium	1	Spends little time actively flying, but some hunting is done while hovering. Soars during sunny days. 10-150 m AGL.	Unpredictable flight behaviour; soars sporadically over western Sea Island during sunny days.	Attracted mainly to large, open areas (e.g., airside) with voles.	Appears to be very tolerant of flying aircraft. Does not appear to habituate to approaches by humans; however, does not exhibit a strong response to unsustained, active dispersal.	Use pyrotechnics in a sustained fashion to control birds in problem areas. Does not require perches in short-grass habitats. Eliminate perches in long-grass habitats in problem areas. Problem birds may require trapping and relocation (see text).
Shorebirds: primarily dunlin	up to 10,000; absent during late spring-mid fall; migrational peaks of several species during mid fall and mid spring; fluctuating numbers of dunlin during mid fall-mid spring.	small	20-5,000	Flies extensively in dense flocks over river, ocean, mudflat, and mowed-grass habitats along western Sea Island. 1-20 m AGL.	Flight behaviour is generally sporadic throughout the day, but appears to be influenced by tides and inland foraging opportunities. Nocturnal activity is suspected, but its extent is unknown. Highly susceptible to disturbances by falcons.	Uses inland sites of short grass and tarmac for feeding/loafing. Uses mudflat habitats for feeding.	Appears to tolerate moving aircraft, but does not appear to habituate to the nearby presence of humans. Effects of unsustained, active dispersal appear to be short-lived.	Eliminate mowed-grass habitats where possible (i.e., grow long grass); use pyrotechnics in a sustained fashion to move flocks from problem areas.

Table 6. Analysis of hazardous birds at YVR.

Group/Species	Maximum Abundance near YVR	Relative Bird Size	Typical Flock Size	Typical Flight Behaviour and Heights (AGL)	Predictability	Habitat Use	Habituation	Mitigation
Gulls	up to 2000; present all year; peak abundance occurs during winter; many gulls only fly past Sea Island between their night roosts and inland feeding sites	medium	1-15	Extensive flights over ocean and river habitats; sporadic flights over all of Sea Island. 5-60 m AGL. Some soaring up to 300 m over Sea Island on sunny days.	Predictable dawn & dusk flights over river channels and over western foreshore; unpredictable flights and soaring over Sea Island during the day. Little nocturnal flight activity. Predictable use of short-grass fields for foraging during winter rains.	Sea Island is located between river channels that serve as movement corridors for gulls between offshore nocturnal roosts and inland foraging/loafing habitats.	Habituates to all forms of disturbance. Effects of unsustained, active harassment are often short-lived.	Eliminate mowed-grass habitats where possible (i.e., grow long grass); use pyrotechnics in a sustained fashion and lethal control to move flocks from problem areas. Distress calls and models/dead gulls can be effective at moving gulls from problem areas.
Barn owl	up to 20; present in relatively constant numbers year-round, with the likelihood of a peak in numbers following the main fledging period in the early summer.	medium	1	Extensive flight activity at night. Flies mostly over vegetated habitats that support voles. Center of abundance on Sea Island is currently SICA. 2-10 m AGL.	Fairly predictable use of habitats that support voles. Owls maintain territories.	Attracted to foraging opportunities of grass fields, hedgerows, and mixed woodland habitats; and roosting and nesting opportunities in airside buildings and woodland habitats.	Given the number of strikes this species has been involved in, it appears to be oblivious to aircraft. Nesting and roosting in hangars indicates high tolerance to non-control disturbances by humans.	Minimize roosting and nesting opportunities in the airside zone.
Northwestern crow	up to 600; number of individuals is relatively constant throughout the year.	medium-small	2-50	Flies throughout Sea Island during the daytime, but tends to avoid actively controlled areas. A peak in flight activity occurs in the evening as they fly to nocturnal roosts off Sea Island. 5-40 m AGL.	Unpredictable flights throughout the day. Predictable eastward flights over northern and eastern Sea Island near sunset.	Attracted to the foraging opportunities of mowed-grass and disturbed habitats. Feeds on mower-killed voles, soil-borne invertebrates, marine organisms exposed during low tide, garbage, "grit". Nests in trees throughout and near Sea Island.	Highly adaptable to non-control disturbances by humans and aircraft.	Eliminate mowed-grass habitats where possible (i.e., grow long grass); use pyrotechnics in a sustained fashion and lethal control to move flocks from problem areas. Distress calls and models/dead crows can be effective at moving crows from problem areas.
European starling	up to 10,000; numbers fluctuate throughout the year; likely dependent on forage availability	small	10-1000	Dense flocks move throughout Sea Island during the daytime, foraging in habitats with low vegetation, or fruit-bearing shrubs. Large flocks gather near dusk and fly eastward off Sea Island to roost. 5-30 m AGL.	Unpredictable movements throughout Sea Island, although typically observed in most habitats with short vegetation.	Feed on soil-borne invertebrates in habitats with short vegetation; feed in habitats with fruit-bearing shrubs; nest throughout Sea Island; particularly in airside buildings.	Highly adaptable to non-control disturbances by humans and aircraft. Appears to habituate to unsustained control methods.	Eliminate mowed-grass habitats where possible (i.e., grow long grass); use pyrotechnics in a sustained fashion and lethal control to move flocks from problem areas. Distress calls and falconry can be effective at moving starlings from problem areas.

Species are listed in taxonomic order.

PROPOSED WILDLIFE CONTROL PROGRAM

Introduction

Any successful wildlife Control program must have regard for the behaviour and other aspects of the biology of the species being controlled. Thus, a WCP must accurately identify the species of wildlife present at the airport and adapt the control techniques to the behaviour and ecology of those species. The collection and assimilation of this information will be instrumental in refining and correctly applying the appropriate techniques to specific situations requiring control.

As the degree to which understanding of the response by wildlife to the WCP improves, the extent to which the approach can be made more adaptive also improves. Routine and methodical application of control procedures may remain effective for a time, but eventually the effectiveness diminishes or a new situation develops for which the original techniques are not suitable. Therefore, this report will not lay out specific methodology that can be followed routinely. The purpose of this report is to provide the conceptual approach and the necessary tools which, when applied properly and in the right circumstances will have a high probability of establishing long-term bird control at YVR. Matching the appropriate methodology to the specific circumstances must be learned through testing in the field by the wildlife controllers based on the typical behaviour of the birds and location of the site relative to air traffic and various wildlife habitat features.

The key aspects of a successful WCP include:

- continuously improving knowledge of species behaviour and ecology related to control;
- selection of appropriate methods of control;
- proper application of control methods;
- adaptation of methods used to suit changing conditions and prevent habituation; and
- adequate staff and resources to effect necessary control at all times.

The approach presented here relies heavily on environmental management and site modification for the control of flocking birds. The need for environmental management extends beyond the airside boundaries and even beyond the shores of Sea Island. Even when the airport habitats are managed appropriately, there is still a need for active wildlife control at YVR. The habitat management and active control components are discussed in the following sections.

Habitat Management

Habitat management options are limited by airport grounds requirements for air safety. However, within those limitations, habitats can be managed to reduce their suitability for hazardous species of birds. Habitat management is critical because it reduces the size of the area that can be used by hazardous species and allows wildlife controllers to focus their efforts on a much smaller area. This is especially important as the Parallel Runway becomes active and greatly expands the area over which wildlife must be controlled.

Airside

Grass

The current prescriptions for species mix and grass heights at YVR are not effective in reducing flocking birds. Conversely, the tall grass in the Sea Island Conservation Area has effectively prevented most flocking birds from this area. It is clear that as long as the current regime of mowing the grass to relatively short heights (e.g., 10-15 cm) continues, there will always be flocks of birds attempting to use those attractive habitats. Therefore, it is important to establish tall grass on as much of the airport as possible. The specific height of grass is in part determined by the density or percent cover of the grass. The goal is to produce a ground cover which is too tall for birds such as shorebirds, gulls, waterfowl, and that is so tall and dense that raptors have a difficult time finding voles to hunt. A large Canada goose stands about 60-70 cm; therefore, grass heights about 75 cm are appropriate. Furthermore, it is important that the grass remain standing through the winter storms and under high rainfall conditions. Therefore, a significant amount of reed canary grass (*Phalaris arundinacea*) or other similar coarse, tall-growing species of grass needs to be established. There is already a significant amount of reed canary grass in the current grass mixture in some parts of the airport which could be left to grow and supplemented with additional reed canary grass seed if necessary. As previously mentioned, it is also important that the grass canopy cover be as close to 100% as possible to make it more difficult for raptors to see voles thereby discouraging them from feeding in these tall grass areas.

The edges of the runway and taxiways contain lights, instruments and signs which must be visible to pilots and, therefore, cannot be surrounded by tall grass. In some cases, signs can be elevated above the grass, but in areas subject to jet blasts all objects must remain close to the ground. Therefore, grass will need to be mowed to the limits of signage along runways and taxiways. All other areas, however, should be established as tall grass.

Several concerns arise regarding the establishment of tall grass. (1) One area, the button of Runway 12, consists of poor soils that do not support much

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growth, especially during summer months. This area may require soil amendments to establish sufficient growth. Alternatively, additional focus on this area by active control methods (see below) may be required. (2) Areas with excessive standing water may not support reed canary grass. In those cases, improved drainage will be required. (3) Airport and contractor's vehicles have typically been driven off pavement areas during dry months which tramples the grass and will provide attractive feeding areas for waterfowl, gulls and raptors. Off pavement operation of vehicles should be minimized, especially during the late summer-fall period.

Ditches

The large network of open ditches on Sea Island attracts numerous dabbling ducks, great blue herons, and northern harriers. There are two long-term solutions to the current situation, both of which involve enclosing the ditches. A solid enclosure would require that drainage pipes be installed in the fields and connected with large diameter pipes that would be located in the current ditches. This has the advantage in that areas of standing water could be drained by this method. However, the cost is likely to be significant. The second method is to place metal grates over the ditch to keep all birds from using the aquatic habitat of the ditch. The grates could be removed for periodic maintenance of the ditch.

Earth Worm Control

Earthworms are a major problem during winter because they are a food source for ducks, gulls and shorebirds. When the ground becomes saturated during and after winter rains, concentrations of birds occur in the wet areas of short grass fields and along the paved runway and taxiway areas. Because it will be necessary to maintain strips of short grass along the edges of runways and taxiways, there is the potential for attracting flocking birds to those areas. Teraclor has been used to reduce the abundance of earth worms at other airports in North America, and, pending the outcome of tests to be conducted at YVR during the fall of 1996, should be considered for use along the edges of runways and taxiways during the late fall — early winter period.

Buildings

The current program of checking all buildings and removing nests must be continued and improved. A list of all airport buildings should be prepared and each building should be inspected regularly throughout the nesting season. All nest should be destroyed and locations where regular nesting occurs should be modified to prevent future nesting. Some nest sites are impossible to either destroy or modify. In these instances, it may be necessary

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to either trap or shoot the adult bird(s). Where possible, buildings should be modified to reduce future nesting attempts.

The design of all new buildings on airport property must be carefully examined by a wildlife biologist that is familiar with the avifauna of Sea Island to ensure that new roosting and nesting locations are not inadvertently created.

Nests of hazardous species built in trees or other locations on and near the airport (with the exception of SICA) should be removed.

Groundside

Airport-owned Lands

To the greatest extent possible, groundside habitats should be managed as tall grass habitats similar to that recommended for airside habitats. Tall-grass habitats can be established in the Commercial Development Reserve and the fields east of the Canadian hangar. Particular attention should be paid to those areas where tall-grass habitats are not established in order to prevent them from becoming attractive wildlife habitats for hazardous species. Individual landscaping plans should be evaluated from a wildlife hazard to aircraft perspective before being implemented.

It is imperative that human access to areas frequented by significant numbers of birds in groundside areas (e.g., east of the Canadian hangar) be prevented during the winter periods when bird numbers are high. Human disturbance to birds in these areas may cause birds to flush into approach/departure paths where they become a hazard to aircraft.

Non-airport Lands

There are a number of areas near the airport that potentially contribute to wildlife hazards at YVR. These areas should be monitored and, if problems are evident, co-operative solutions negotiated. Because these sites are not controlled by YVRAA or Transport Canada, it is important to emphasize co-operation especially in view of the fact that there may be some liability implications to the property owner and tenant.

The major known areas of concern include SICA, the GVRD Sewage Treatment Plant, the GVRD Iona Beach Park, and Sturgeon Bank and the foreshore of Sea Island. Other areas that require further investigation include the meat packing plant near Sea Island, the local solid waste transfer station, and area landfills.

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SICA has been the subject of extensive study. A management plan has been developed that explicitly lays out how the area is to be managed both as a conservation area and with respect to bird hazards. The terms and conditions of WCP operations within SICA are also defined. It is important to continue to monitor the extent to which birds from SICA occupy airside areas and the amount of wildlife control required within SICA. Wildlife controllers should be thoroughly familiar with the SICA management plan and the terms and conditions under which the WCP can operate within SICA.

The GVRD Sewage Treatment Plant facilities creates a strong attraction for gulls, crows and European starlings. It is unlikely that modifications can be made to reduce this attraction. However, the plant operates a "grit dump" which further attracts these species plus several others (e.g., rock doves, raptors). Persistent efforts should be made to negotiate the closure of this dump. Until a new location for the materials currently being dumped at the GVRD site is found, efforts should be made to insure that the GVRD operate the site as a landfill by covering the newly dumped grit immediately.

Active Wildlife Control

Approach

While most birds at YVR can be controlled through proper habitat management, some birds will require additional active control. More significantly, considerable portions of the airport cannot be maintained as tall grass habitat (e.g., runway edges, foreshore, terminal areas). Active wildlife control in these areas will be required to disperse birds that attempt to use those locations. Furthermore, the establishment of tall grass at YVR will take some time. During the transition from the current short-grass habitat to the eventual tall-grass habitat, large numbers of birds will continue to use YVR and their control will require active methods.

There are a number of factors that influence the success of any wildlife control program. These factors include:

- an understanding of the behaviour and response of the animal being controlled;
- proper application of the technique being used;
- variation in the technique and application to reduce habituation; and
- proper integration of methods.

These factors are briefly discussed in the following paragraphs.

Unless the behaviour and other aspects of the ecology of the animal being controlled is adequately understood, efficient and effective control is unlikely

to be achieved. An understanding of why animals are engaged in certain activities, in specific locations, at particular times helps to determine the motivation of the animals to be in an area and the options that are available to those animals when they are dispersed. For example, if no other options are available to the animal, it is unlikely that intermittent control efforts will be successful and more likely that continuous control will be required. It should also be noted that if it is known that a species is attracted to a certain set of conditions at YVR, those conditions can either be eliminated, or if this is not possible, at least the situation can be predicted and suitable control measures put in place to control the species before a hazardous situation develops.

The most common cause of the failure of bird control techniques is improper application of the technique. While many methods appear to be straightforward, even subtle errors in their application can render them ineffective. Not only is it important for wildlife controllers to receive proper training when they are hired, it is also important to periodically update their training to correct errors that develop over time.

Just as wildlife habituate to natural stimuli that are not dangerous, they also habituate to control methods that they learn are not threatening. Proper application of the selected method is critical to discouraging habituation. Also, varying the methods used and the way in which methods are used reduces an animal's familiarity with specific techniques and, thereby, reduces the likelihood of habituation.

One key to minimizing an animal's habituation to stimulus is to reduce the predictability of that stimulus. There is a need to diversify the control methodology used at YVR. Although the current WCP espouses the use of alternate methods, in reality the only significant methods used are pyrotechnics and killing birds. Better integration and combination of control methods are very important in the ongoing control program at YVR because it will ensure that each time an animal is controlled it is a novel event (to the animal) rather than a routine activity.

It is critical that hazardous species are not allowed to feed or loaf on the airport at any time. With consistent and persistent control, hazardous wildlife will eventually be discouraged from using the airport.

Equally important is that control must extend beyond the airside fence. It is not sufficient to disperse birds from airside only to have them land in the Commercial Development Zone and return to airside areas a few minutes later. As a general rule, once control is initiated, it should be maintained until birds have been moved to suitable areas at distances from airside which

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will minimize their likelihood of returning to airside in the short term or until it is logistically impossible to continue control actions.

Pyrotechnics

Pyrotechnics will remain the major active control technique at YVR. However, pyrotechnics should be used more sparingly over the entire airport. The number of shots fired by wildlife controllers should be minimized in order to reduce habituation of birds to pyrotechnics. If birds flush when the wildlife controller's truck approaches, then it is not necessary to fire a shot at them, and if one shot moves a flock of birds, then two or three shots are not needed. Because pyrotechnics are an important component of the WCP, it is critical to prevent habituation of birds to this technique as much as possible.

One very important factor in the use of pyrotechnics which has consistently been violated during past control efforts at YVR is that pyrotechnics should never be fired unless the explosion is close to the animals being controlled. This is very difficult to do in an open airport setting and makes pyrotechnics a difficult method to employ effectively. Nevertheless, much of the current lack of persistent control effectiveness for birds at YVR can be attributed to this lack of proper application of the technique. The effectiveness of pyrotechnics can be greatly enhanced by varying the types of pyrotechnics used (e.g., bangers, screamers, crackers) and use of weapons (e.g., pistol, shotgun). This presents a variety of sounds with a variety of ranges and does not allow animals to anticipate the stimuli or the range. A new pyrotechnic called the 'CAPA' anti bird-strike cartridge has recently been developed that has a much greater range and should be incorporated into the mixture of pyrotechnics used at YVR.

Wildlife controllers need to be more tenacious when moving individual flocks and clearing areas of birds. When control of priority species is required, it is necessary to stay with the bird or flock of birds and repeatedly use pyrotechnics or a combination of pyrotechnics and other techniques to drive the bird or flock well away from the airport. The need for persistent control will likely require a second wildlife control officer to maintain the general patrol while the first officer is engaged in intensive control of individual birds and flocks.

Distress Calls

Many species of birds give distinctive calls when being harmed (distress calls) or when threatened or attacked (alarm calls). Distress calls and alarm calls are generally species specific, thus only other members of that species typically respond by fleeing the area although other species may respond to the distress or alarm calls of species they typically associate with. By recording the alarm

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and distress calls of birds, then subsequently playing the calls through a loudspeaker, a means of wildlife control is achieved. Limited use of distress calls can effectively move flocks of European starlings and can help to reinforce pyrotechnic methods for gulls.

Recordings of the distress calls for the glaucous-winged gull, Thayer's gull, mew gull, northwestern crow and European starling should be obtained using local birds. All recording should be done by qualified personnel using high quality sound recording equipment. These recordings should then be appropriately incorporated into the control routine.

Great care must be exercised when using distress calls near active runways. For example, gulls will approach the source of the distress calls and will circle overhead before leaving the area. Thus, distress calls should not be used near active runways.

Lethal Control

The killing of birds has two purposes in a control program. The first purpose is to destroy a bird when all non-lethal means of control are ineffective or inappropriate. The second purpose is to reinforce the responses of the birds to non-lethal methods of dispersal. Typically, small numbers of gulls, northwestern crows and European starlings are killed at YVR. Although data are not sufficient to evaluate the effectiveness of lethal control at YVR, experience gained from other programs indicates that its use should continue. It is important that birds are only killed strategically to reinforce non-lethal control methods or to remove the immediate and imminent risk of a strike.

Models

The use of freshly killed or stuffed birds, especially when mounted in specific postures, to reinforce the effects of pyrotechnics, distress calls and lethal control should be done periodically at YVR. Overuse of this technique leads to rapid habituation. However, limited, strategic use can be very effective in dispersing birds such as gulls and can enhance the effectiveness of pyrotechnics and distress calls even when subsequently used without the models. It is important not to leave the model in the field for extended periods.

Visual Harassment

Many of the birds that are routinely controlled at YVR learn to recognize the appearance of the wildlife controllers' truck. As a result, it is often difficult to approach birds to within range of the technique used (generally pyrotechnics).

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There are two aspects of this learned behaviour by birds that can be used to advantage. First, if birds disperse at the mere approach of the wildlife controllers' truck, then the truck itself is a useful deterrent. No pyrotechnics or other dispersant are required while the truck elicits the desired response. Second, if birds respond to the specific truck used by the wildlife controllers, then exchanging vehicles periodically with other agencies or using personal or rented vehicles if suitably equipped can alter the response. This may result in birds avoiding all vehicles on the airport which may greatly expand the effective control applied during operational hours.

In order to effectively use most methods of control, they must be operated within range of the animals being controlled. Therefore, having birds respond to the wildlife controllers' truck well before it is within range, severely limits the methods of dispersal available for use. The presence of a vehicle will not provide long-lasting control and needs to be supplemented with more effective control. In order to be in a position to administer more effective control, it is necessary to approach birds within range. In areas that are known to regularly harbour concentrations of birds, it may be reasonable to set up a number of blinds which can be occupied periodically by a wildlife controller. When bird numbers warrant, the wildlife controller disperses these birds with a suitable device from within the blind. In time, the presence of the blind will be adequate to provide some measure of deterrent to birds especially when it is periodically occupied by a wildlife controller.

Sonic Harassment

A variety of other control methods are available that can be grouped under 'sonic devices'. Most of these methods have limited effectiveness, but the importance in their periodic use is in adding diversity to the WCP which minimizes habituation to the program. Horns, sirens and electronic noise and sound generators are the most common types of devices in this category used to disperse birds. Periodic use of these methods should be made, especially in situations that are less critical to air safety (e.g., away from the runways).

Phoenix Wailers

Phoenix wailers cannot be relied on to provide effective control of birds along the runways at YVR until their effectiveness is demonstrated. Previous studies have not demonstrated their effectiveness in any defensible studies. Therefore, YVR should conduct a scientific study to assess the effectiveness of the Phoenix wailers at the end of Runways 08R-26L and 12-30 and base future use of the wailers on those results.

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Lights

Truck-mounted and hand-held halogen lights (i.e., greater than 500,000 candlepower) are effective means of illuminating the airfield at night to determine the presence of birds. Such lights are also somewhat effective at dispersing birds. Birds that are not dispersed by the light should be chased away with pyrotechnics or other devices. Care must be taken to ensure that the lights do not interfere with the vision or attention of pilots.

Boats

Because birds at YVR are not restricted to the land, it may be necessary to continue bird control onto the water areas surrounding Sea Island. For this purpose, it is necessary for the wildlife controllers to have access to a boat suitable for travel in the shallow waters of Sturgeon Bank. Initially, a boat will be required to resolve two major problems that occur at YVR.

(1) Gulls roost on Sturgeon Bank southwest of YVR and make daily flights along the Middle Arm of the Fraser River crossing the flight path of Runway 08R-26L. Because these birds are likely heading to a wide variety of feeding locations in and around Vancouver, the most reasonable solution to deter movements of gulls along the river is to attempt to move the roost site further to the south. From a more southerly origin, gulls are likely to take a different route to and from their familiar feeding sites (e.g., the South Arm of the Fraser River). Persistent evening control would be required from one or more boats to cause gulls to relocate their roost site. Pyrotechnics would likely be most appropriate to disperse gulls. Activities should be initiated before gulls begin to congregate at the roost and continue until after dark. The Coast Guard hovercraft would be a very useful vessel if cooperative arrangements could be made. The noise of the hovercraft and the onboard lights would add greatly to the control methods employed, and the speed and zero-draft of the vessel would make it ideal to pursue and disperse gulls forcing them further to the south.

(2) It is essential to prevent snow geese from using the foreshore of Sea Island. To a large extent, this can be accomplished by using pyrotechnics and live ammunition from the approach lighting jetty at the base of Runway 08R-26L as birds approach Sea Island. However, many snow geese congregate along the western edge of Swishwash Island in the mouth of the Middle Arm from which it is a very short flight to Sea Island. This area is also under the approach used by float planes which tend to take a much lower approach than wheeled aircraft. Therefore, snow geese should also be prevented from gathering on Swishwash Island. Control of birds in this area can only be done from boat (or from the island which requires a boat to get there). Again, the

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hovercraft would be very effective for controlling geese (and other waterfowl) in this area if arrangements could be made for Coast Guard assistance.

Trapping and Releasing Raptors

This WCP calls for extensive areas of tall grass. These areas are prime habitats for Townsend's voles which are the preferred food item of most of the wintering raptors and owls on Sea Island. The tall and very dense grass cover is intended to both deter flocking birds from using the area and prevent birds of prey from easily finding voles. While it is not anticipated that raptor populations will increase dramatically with the tall grass prescription, it is possible that their numbers may increase and that their movements may extend airside to a greater degree than presently experienced. Therefore, it may be necessary to focus attention on raptors to a greater degree than presently required. To this end, a trap and release program may be required.

Trap and release programs for raptors are conducted at several airports in North America, including Lester B. Pearson International Airport in Toronto, Ontario. The objective is to trap raptors that are actually using the airfields and to transplant them at considerable distances from the airport with the expectation that they will settle away from the airport. Due to a tendency of individual raptors to over-winter in the same area each year, trapped raptors must be released into suitable habitat at a location that is sufficiently far away from the airport that the probability that they will return is low. For example, raptors trapped at Pearson International Airport are released at least 100 km away.

A potential problem with this technique at YVR is that if the traps capture raptors resident in SICA during the limited time they spend away from SICA, the loss of these birds would compromise the conservation values of that area. Further, the loss of resident red-tailed hawks from SICA could result in an increase in the number of raptors adjacent to the airfield. This sequence of events could occur because resident hawks appear to defend a larger territory (and therefore occur at a lower overall density) than that held by non-resident hawks. Furthermore, resident adult hawks are likely to be more familiar with aircraft and avoid them whereas replacement birds are likely to be less familiar with aircraft and thus more likely to be struck. In these ways, increasing the number of raptors adjacent to the airfield by removing resident birds would likely compound hazards to air-traffic safety.

The need to release trapped raptors at a large distance from the airport will present logistical challenges. During the winter, suitable habitat is most limited. Furthermore, most release sites that are at least 100 km away from YVR are located in the United States. However, it is likely that immature birds do not have to be released as far away as adults. If the trapping program

focused on immature raptors, the logistical challenges associated with releasing the birds might be ameliorated. In any case, all birds that are trapped should be banded with a non-metallic leg band that is visible from a distance in order that recaptures be identified as such. Leg bands will also permit the visual identification of banded birds should they return, but fail to be trapped. At a minimum, data on each capture and release should identify species, age, date trapped, location, trap type, leg-band number, release date, release location. Birds that are released a second time must be released even further away from YVR than they were initially.

In summary, there are several advantages and disadvantages to a raptor trap and release program. The advantages of the program are that trapping helps to resolve specific problems by removing individual birds in problem areas and may tend to reduce the number of raptors present at the airport. The disadvantages are that there may be a higher turnover of wintering raptors present which may actually increase number of birds and result in more birds that are unfamiliar with aircraft and may have a higher tendency of being struck. Once initiated there may be a need to continue trapping all winter in order to keep the area free of immigrant birds. Additionally, there is no guarantee that relocated birds will not return to the airport.

Because it is not clear that a trap and release program is appropriate at YVR, before embarking on such a program the existing territorial raptors should be captured and marked in order to determine the influence of territoriality on their movements and the movements of other raptors and their individual behaviour especially as it relates to experience with aircraft. With this information, an assessment of the suitability of a raptor trap and release program can be made.

Raptor trapping and relocating should be initiated only if problems arise with raptors on the airfield and cannot be resolved by dispersal techniques. The relocation program should be limited to raptors other than bald eagles and adult red-tailed hawks unless there are compelling reasons to remove problem individuals of either of these two types. Because raptors are typically found in the same general area each day, the trap-and-release program can focus on problem birds at specific locations. A refined approach, rather than a more widespread, indiscriminate one will be more successful as well as more acceptable to non-airport parties.

Perching Deterrents

Although there are innumerable perch sites at the airport, key and heavily used sites, especially near runways, should be treated with Hotfoot and maintained as required. This form of control can be effective for species such as the red-tailed hawk because it prefers to hunt from a perch. Nix-a-lite

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should be used in highly problematic areas where no other solution can be found.

Other Techniques

Falconry

Falcons can be used to disperse shorebirds, gulls, rock doves and smaller passerines from areas where they present hazards to aircraft. Falconry is an integral part of the WCP at Lester B. Pearson International Airport in Toronto, but is not widely used at other civil airports in North America. The use of falconry is dependent on the availability of qualified falconers with a considerable number of birds. According to Wilf Emonts of Intercept Wildlife Control (the control contractor at Lester B. Pearson International Airport), only peregrine falcons are physically adapted to perform in the wet weather conditions at YVR.

The use of falconry at YVR should only be considered if there are significant problems which the WCP is not able to resolve and information suggests that falconry has the potential to be effective in controlling the problems. If falconry is then implemented, its effectiveness must be carefully monitored and assessed. The use of falcons requires staff with specialized experience as falconers.

Dogs

The use of trained dogs in wildlife control at airports is an unconventional, though promising, method which should be considered in certain situations. At YVR, dogs are likely to be of greatest use with waterfowl, especially at night when waterfowl are not easily seen and there are few aircraft movements to be concerned about. Herding dogs, such as border collies, are likely to be most effective because they can be tightly controlled and tend to move birds on the ground rather than flush them into the air. Dogs need to be trained to work with birds and to not be gun-shy because the combined use of pyrotechnics will likely be required.

Because of the expense and commitment (kennels, animal care, food, veterinary costs, etc.) dogs are not recommended at this time. However, if problems that could potentially be resolved with the use of dogs persists, it would be worth experimenting with the use of dogs. Initially, a trainer with his/her own dogs should work with a wildlife biologist to develop a suitable control system that can eventually be taken on by the wildlife controllers.

Hours of Operation and Personnel

It is critical that wildlife, particularly birds, are controlled at YVR 24 hours per day. Only by continually reinforcing the fact that the airfield is not a desirable place for a bird to be can bird use of the area be constantly suppressed. Although YVR is used by air traffic 24-hours a day, there is a marked decrease in the number of flights during the night compared to the day. As a result, the night offers an opportunity to carry out extensive control work that may otherwise not be possible during the day when aircraft movements are frequent.

At a minimum, there should be at least one wildlife controller on duty at all times from October through April. Beginning at 0500 and continuing until 2000, there should be a minimum of two officers on duty at all times. During the period of May through September, there should be a minimum of one wildlife controller on duty from 0500 until 2200. At the present time, an on-duty wildlife controller from 2200 until 0500 during May through September does not appear to be warranted. If a problem needs to be addressed during those times, the Airside Duty Manager should be capable of responding. Shift timing for the wildlife controllers should not be so rigid that they go off duty at 2200 if a problem persists at that time. At least one wildlife controller or the Airside Duty Manager must be on call to respond to off hour wildlife control requirements. It is also important that pre-set routes are not followed by wildlife controllers in order to prevent birds from habituating to the route and the timing between control events.

During periods of intense, unanticipated bird activity, the Airside Duty Manager should also be used to supplement the manpower of the WCP. These managers are trained in the basic use of wildlife control tools and could be helpful when large numbers of birds occur airside.

Integration with Airport Operations

Prior to the operation of the Parallel Runway, the entire northern half of Sea Island served as a "receiving area" into which birds could be safely dispersed. Operation of the Parallel Runway will not merely expand the area over which the WCP must operate, it will pose many logistical challenges to bird dispersal. With three runways, extreme caution must be exercised when birds are dispersed from one area to ensure that they do not become a hazard to aircraft at another location. For this reason, the need for communication between the wildlife controllers and tower personnel is critical. In this way, dispersal activities can be timed to occur when there are no arriving or departing aircraft in the vicinity.

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Many activities in and around the airport affect the distribution and abundance of birds and the ability of the WCP to minimize the hazards caused by birds. Communication of wildlife control concerns is an essential element in maintaining a safe environment from a bird hazard perspective. Also, coordination of activities taking place at the airport with the WCP is critical. Whether those activities are initiated by the Airport Authority or outside agencies, the affects of actions taken at or near the airport on the wildlife control program must be evaluated before activities commence. Therefore, the manager of the WCP should be involved in all YVRAA actions that have the potential to affect wildlife abundance, distribution, movements or the capability of the wildlife controllers to perform their duties unimpeded. This involvement may range from review and comment to a participating member of a board or committee. At a minimum, the WCP must be represented in actions taken by the Environmental and Grounds Maintenance Divisions of YVRAA.

It is also important to obtain standing for the WCP with other agencies that may influence wildlife hazard conditions on Sea Island. Such groups include SICA managers, GVRD (both Iona Beach Regional Park and the Sewage Treatment Plant), the Municipality of Richmond, and possibly others that may be necessary from time to time such as the Musqueam Band, the Harbour Commission, Canadian Wildlife Service, Coast Guard, etc. The WCP manager will be required to keep abreast of events taking place in the Sea Island area, assess their potential impact on hazard conditions at YVR, and make the necessary provisions for having the required input to ensure continued success of the WCP and safety of YVR.

WILDLIFE CONTROL AT OTHER AIRPORTS

Bird hazards and control are not unique to YVR, but are present at most major commercial airports in North America. As part of the WCP at YVR, regular contact with other airports to compare approaches, problems and solutions will help keep the WCP current, will insure that the WCP manager is informed, and may reduce liability if it can be shown that YVR has carefully considered all existing approaches to wildlife control currently in use at comparable airports. To begin this process, we have contacted eight major airports in North America. A synopsis of their wildlife control programs are presented in Table 7. Among the airports surveyed, YVR stands alone as the airport that contends with hazards from the largest array of species for the greatest length of time each year.

Table 7. Summary of wildlife control at selected major airports in North America.

Airport	Number of Officers/ Hours of Operation	Methods			Major Problems	Species of Greatest Concern	Evaluation	Average Number of Strikes per Year
		Active	Habitat Management	Other				
Seattle-Tacoma	2 officers 24 hours	cracker shells distress calls dead gulls some lethal control perch control	no mowing after 1 July tall grass to 75 cm	used night vision equipment in past	Surface water	European starlings gulls waterfowl raptors galliformes	set and achieve goals daily wildlife activity reports	15 (reported and suspected)
Portland	1 operations supervisor 24 hours 1 assistant 8 hrs/day M-F	cracker shells poison voles trap & relocate coyotes	short grass to 15cm fill in depressions		Surface water Zinc phosphide (vole poison) in ground water	waterfowl gulls European starlings coyotes	records of sightings and dispersal compared over time number of bird strikes	40 (confirmed and unconfirmed)
San Francisco	no dedicated personnel	cracker shells lethal control	very short grass		gulls during storms	gulls raptors	none	
Los Angeles	2-3 operations personnel conduct wildlife control as needed during daytime hours	pyrotechnics some lethal control warn tower of birds	short grass year round		gulls during storms	rock doves gulls	records of sightings and dispersal	<10
Atlantic City	5 officers during summer dawn-dusk 7 days/week	cracker shells lethal control	grass 25-35 cm	deer fencing		laughing gulls waterfowl European starlings American kestrels tree swallows	records of sightings and dispersal compared over time number of bird strikes	<5
Edmonton	1 officer from 8-5 M-F Emergency response personnel and duty officer cover rest of day	pyrotechnics propane canon at night lethal control poison rodents distress calls	grass mowed to 10-12 cm 3400 ha in no-till winter wheat	hourly scans by tower to direct WCP officer	Surface water	gulls waterfowl	number of bird strikes	10-15
Ottawa	1 biologist from 8-4 M-F Other supervisors carry pyrotechnics for control at other times	pyrotechnics propane canons distress calls raptor trap & removal lethal control of geese	fill in areas of standing water manage creek habitats mow grass 6AM-2PM daily	signs to educate public not to feed birds wire grid over creek	deer kills retention pond in the middle of the airport	gulls geese hawks	number of bird strikes daily records of sightings	30-40
Toronto - Pearson	1 officer dawn-dusk	falconry pyrotechnics distress calls lethal control raptor trap and removal					number of bird strikes	80

MONITORING AND REPORTING

Although it is tempting to simply examine the number of bird strikes by aircraft and assume that if strikes are down the program is successful, this approach is fraught with difficulties that limit its utility. As a result, many airports keep some form of records on the number of birds that occur in the immediate vicinity of the airport. Some airports partially evaluate the success of their programs by making yearly comparisons of consistently collected numbers. In theory this approach holds promise, but discrepancies in the manners in which these data are collected limit the utility of this approach.

The only way to obtain a benchmark that will allow the effectiveness of a wildlife control program to be evaluated, is through the careful collection, analyses, and interpretation of accurate data on strikes, bird abundance, and control effort. Current Transport Canada initiatives are striving to standardize the methods by which bird strike data are recorded and reported. Considerable effort is and will continue to be focused on collecting more accurate and complete bird-strike data. Although bird abundance data has been collected by various agencies over the years at YVR, there is no consistent, long-term program of data collection that is specifically designed to inventory hazardous species of birds that occur on and near YVR. Monthly and annual summaries of the WCP focus on the number of birds controlled, but no emphasis is placed on the number of times a particular species is controlled or the number of birds that are using adjacent habitats. Because "control" is more than merely flushing the birds, information on bird responses must also be recorded to provide feedback on the effectiveness of the control.

To ensure that the WCP is performing effectively and that attempts to mitigate all hazards are made, data pertaining to local wildlife populations and the WCP must be collected, analyzed, and interpreted consistently and thoroughly.

Data Collection

Bird Strike Data

Bird strike data must be collected consistently from year to year. Strike definitions should be those standardized by Transport Canada and information collected about each strike should match that requested by Transport Canada. A bird strike reporting form (TP12422, Form 51-0272) should be filled out and submitted to Transport Canada for every known strike at YVR. In addition to the information requested by Transport Canada,

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the exact location of the strike (when known) should be collected and mapped. These data, when analyzed by species, time of day, time of year, type of aircraft are likely to reveal specific hazardous locations that require efforts by wildlife controllers.

Wildlife Control Data

The data required for evaluation of the WCP are essentially those currently being collected with the addition of the number of control events rather than simply the number of birds controlled. The following paragraphs present suggestions for structuring the data into databases that will facilitate annual and multi-year analyses.

The database into which data from the "Daily Log" sheets are entered should be restructured to facilitate the automatic generation of summary reports and statistical analyses. The datasheets would consist of two parts: a heading database and a body database. The heading database would be structured as follows:

Date	Initials	Shift Hrs.	Km Driven
12-Mar-96	ABC	8.5	155
etc.			

1. Date: (alpha-numeric) given in the format: ddmmmyy.
2. Initials: (alpha) the three initials of the control officer are given.
3. Shift hrs: (numeric) number of hours of the current shift.
4. Km driven: (numeric) number of kilometers driven during the current shift (as per the trip odometer).

The body database would be structured as follows:

Event	Time Start	Time End	Species	No.	Location	Control	No. Used	Behav 1	Behav 2	Comments
1	1443	1445	AMWI	250	B4	9	1	1	8	
1	1443	1445	AMWI	250	B4	10	2	1	23	
etc...										

1. Event: (numeric) enter the number of the event so that each day the first event is number 1. For events where more than one means of control is deployed (e.g., pyrotechnics and distress calls), each means of control will have a separate entry, but the event number will be the same for both.
2. Time start: (numeric) entered as 24-hour time (no colon) when control began.

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3. Time end: (numeric) entered as 24-hour time (no colon) when control ended.
4. Species: (alpha) four-letter species code.
5. No.: (numeric) number of birds to be controlled.
6. Location: (alpha-numeric) location code as per map.
7. Control: (numeric) code of control method.
8. No. used: (numeric) number of each control type used (field may not be applicable).
9. Behav 1: (numeric) code of animal behaviour prior to control.
10. Behaviour: (numeric) code of animal in response to control.
11. Comments: (alpha) any relevant observations/comments.

The reporting of wildlife incidents (strikes, recovered carcasses, remains submitted for analyses, etc.) would continue as per the current Transport Canada protocol.

Bird Surveys

Data recorded in the daily log offer important insights into the nature of bird control, but that information alone is incomplete. For example, without information on the abundance and distribution of hazardous species around the airport, it will not be possible to determine if a reduction in control efforts in any given year are the result of the WCP's effectiveness or simply indicative of a reduction in the number of birds occurring in the general vicinity of YVR during the same period.

The species and numbers of birds at any given location in the vicinity of YVR are changeable. In order to keep abreast of the local bird-hazard situation, it is important that these changes in the local avian community be monitored. At a minimum, monitoring of local birds should be conducted bi-weekly during the over-wintering period and monthly outside that period. With minor modifications in the survey route, the technique used for the "post-breeding bird surveys" conducted under contract to Transport Canada during 1994-1996, is suitable. Surveys should be conducted consistently along a standard route, and be done under similar conditions with respect to tide height and time of day. These data cannot and should not be collected by wildlife controllers. An independent observer should collect the bird abundance and distribution data.

Reporting

Summary Reports

Summary reports would be prepared from the daily log reports and the bird surveys. The number of summary reports prepared each year would be the same as the number of times the Wildlife Control Committee convenes (e.g.,

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if the Committee meets quarterly, four summary reports would be prepared each year). These summary reports will contain the following information:

- A. Period covered (e.g., 1-MR-96 to 30-JN-96);
- B. Contractor's name: name of wildlife control contractor;
- C. Wildlife controllers on duty: list the names of all officers that worked during the current reporting period;
- D. The following information would be presented in tabular format:

Species	Month	Number of Individuals	Number of Events
CAGO	March	#	#
CAGO	April	#	#
CAGO	May	#	#
CAGO	June	#	#
CAGO	TOTAL	#	#
DUNL	March	#	#
etc...			

- 1. Species: (alpha) indicate the four-letter species code. Species are presented in order of decreasing abundance.
 - 2. Month: (alpha) indicate the month.
 - 3. Number of individuals: (numeric) present the total number of birds of each species that required control.
 - 4. Number of events: (numeric) present the number of events involving each species.
- E. Data will be presented by species by month, with the totals for each species for reporting period being summarized.

Control Technique	Number Used	Number of Events

- 1. Control technique: (alpha) indicate code of each method of wildlife control used during the reporting period.
- 2. Number used: (numeric) indicate the number of each pyrotechnic device used.
- 3. Number of events: (numeric) indicate the number of events in which each control method was used.

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- F. Present a cross-tabulation of the numbers of each species controlled by the location code:

AMWI	256	777	343	2		...
SNGO	45	55	643	22		...
BAEA	2	4	1	0		...

- G. Indicate any measures that, in the opinion of the wildlife controllers and WCP manager, might reduce bird hazards to aircraft if implemented. Such measures include any possible changes to the physical structure of the airport environment, changes to airport operations and activities, and changes to the WCP.
- H. Presentation of the bird survey results; listing survey date, the number of each hazardous species/group, and a generalized map of bird locations.

Annual Reports

An annual report of the WCP's activities would be prepared at the end of each calendar year and submitted to the Wildlife Control Committee for review. The purpose of the report is to summarize the data collected during the previous year, and subject them to analyses that have the potential to identify deficiencies in the WCP and to serve as a standard by which the efficacy of certain control measures can be assessed. At a minimum, the report will contain the following information:

- A. A tabular summary of the number of individuals and the number of control events for each species during each month and the whole year:

Species	Month	Number of Individuals	Number of Events
CAGO	January	#	#
CAGO	February	#	#
CAGO	March	#	#
CAGO	April	#	#
CAGO	etc...	#	#
CAGO	TOTAL	#	#
DUNL	January	#	#
etc...	etc...	#	#

1. Species: (alpha) indicate the four-letter species code.
2. Number of individuals: (numeric) present the total number of birds of each species that required control.

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3. Number of events: (numeric) present the number of events involving each species.

- B. A tabular summary of the number of each control device and the number of events in which they were used for each month and the whole year:

Screamer	January	#	#
Screamer	February	#	#
Screamer	March	#	#
Screamer	April	#	#
Screamer	etc...	#	#
Total Screamer		#	#
Crackers	etc...		

1. Control technique: (alpha) indicate each method of wildlife control used during the reporting period.
2. Number used: (numeric) indicate the number of each pyrotechnic device used.
3. Number of events: (numeric) indicate the number of events in which each control method was used.

- C. A cross-tabulation of the numbers of each species controlled by the location code:

AMWT	256	777	343	2	...
SNGO	45	55	643	22	...
BAEA	2	4	1	0	...

- D. A histogram that presents the total number of each species controlled, and another histogram that shows the total number of events that each species was involved in. Data would be presented in order of decreasing magnitude from left to right along the horizontal axis.
- E. A histogram that presents the total number of times each control technique was used, and another histogram that shows the total number of events that each technique was deployed in (regardless of how many were used per event). Data will be presented in order of decreasing magnitude from left to right along the horizontal axis.
- F. Tables indicating the total numbers of each species or group of species engaged in each of the observed behaviours prior to harassment, and the total numbers of each species according to their responses.

- G. An evaluation of the diversity of the approaches to control each species/group; identifying any patterns of consistent uses of techniques that are causing, or could promote, habituation.
- H. Recommendations and requests that will improve the efficacy of the WCP. This information might suggest modifications to the habitat or habitat management, equipment requirements to perform the job of control more effectively, or identify situations that contravene any guidelines for air safety at the airport.

Three- to Five-Year Review and Plan

Every 3-5 years, the effectiveness of the wildlife control program should be examined in the context of external factors such as climate changes and trends in the numbers of hazardous species that occur provincially. In addition, the activities of the WCP over the coming 3-5 years should be planned and presented (e.g., filling-in of surface depressions, installation of drainage tile, modifications of buildings).

The WCP at YVR will continue to operate for a long time. It is important to begin building a library of historical reference information. Not only will these reports be valuable in ensuring that the WCP at YVR remains as effective as possible, but they will serve as hard evidence of YVRAA's progressive commitment to air-traffic safety at YVR.

PERMIT REQUIREMENTS

Many aspects of the WCP require special permits before they can be legally deployed. Wildlife at YVR fall under two jurisdictions depending on whether they are migratory or not. Migratory birds are regulated federally, while non-migratory birds and mammals are regulated provincially.

Under the provincial Wildlife Act, the harassment or destruction of any bird, its egg, or nest (active) requires a special permit from the British Columbia Ministry of the Environment (MELP) except for northwestern crow, house sparrow, European starling, rock dove, and brown-headed cowbird. Special permits from MELP are required to destroy the nests (active or inactive) of eagles, peregrine falcon, gyrfalcon, osprey, herons, or burrowing owl. Special permits are required to harass, capture, or kill any mammal, except: rough-skinned newt, American bullfrog, snapping turtles, Virginia opossum, Townsend's mole, coast mole, European rabbit, grey squirrel, deer mouse, house mouse, voles, Norway rat, skunks, raccoon.

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Under the federal Migratory Birds Convention Act, the killing, capturing, taking or disturbing of migratory birds or the damaging, destroying, removing or disturbing of nests is illegal except under permit from the Canadian Wildlife Service. The Canada Wildlife Act protects marine plants, animals and habitats and is also administered by the Canadian Wildlife Service. It is unlikely that this act would affect activities conducted under the WCP. Any permits required under this act would be obtained through the Canadian Wildlife Service.

The WCP manager should become familiar with each of these legislative acts in order to ensure that YVRAA complies with the applicable statutes and obtains all necessary permits and licenses from the appropriate agency in order to carry out wildlife control at YVR.

APPENDIX 13

Wildlife Management Software Tools

WILDLIFE MANAGEMENT SOFTWARE TOOLS

Prepared by

**J. D. Phyper
Environmental Software Associates Ltd.
Toronto and Vancouver**

**PROPOSE SOFTWARE TOOLS
TO ASSIST AERODROMES & AIRPORTS
COMPLY WITH PROPOSED LEGISLATION**

- 1) WILDLIFE DATA MANAGEMENT TOOL**
- 2) AUDITING TOOL**
- 3) INTERACTIVE CD ROM TRAINING TOOL**

BACKGROUND ON ENVIRONMENTAL SOFTWARE ASSOCIATES LTD.

- **STARTED IN 1992 - SERVICING CLIENTS IN CANADA, U.S., AND THAILAND**
- **OVER 90 ORGANIZATIONS EMPLOY OUR PRODUCTS INCLUDE TRANSPORT CANADA, CANADIAN DEPARTMENT OF DEFENSE, HEALTH CANADA, PARKS CANADA, PUBLIC WORKS AND THE POLLUTION CONTROL DEPARTMENT OF THAILAND**
- **12 COMMERCIAL PRODUCTS WHICH ADDRESS MANAGEMENT OF ENVIRONMENTAL DATA, AUDITING AND TRAINING**

1) WILDLIFE DATA MANAGEMENT TOOL

DATA FIELDS

- **DATA PERTINENT TO ECOLOGICAL STUDY AND RISK ANALYSIS**
- **DATA PERTINENT TO WILDLIFE CONTROL MANAGEMENT PLAN**
- **DATA PERTINENT TO TABLES 1-5 OF THE PROPOSED LEGISLATION:**
 - **Aerodrome Habitat and Food Sources Related to Wildlife Hazards**
 - **Off-Aerodrome Land Uses & Food Sources Related to Wildlife Hazards**
 - **Management Functions Related to Wildlife Hazards On or In the Vicinity of Aerodromes**
 - **Bird Control - Aerodromes**
 - **Mammal Control-Aerodromes**
- **DATA ON TRAINING PROGRAMS, E.G. COURSE NAME, ATTENDEES' SCORES, ETC.**
- **MAPS CONTAINING INFORMATION ON BIRD MIGRATORY PATTERNS**

1) WILDLIFE DATA MANAGEMENT TOOL

LINKAGES

- **GIS EMPLOYED BY USER (e.g. ArcView)**
- **CURRENT TRANSPORT CANADA WEBSITE FOR WILDLIFE CONTROL**

REPORT GENERATION

- **REPORT, INCLUDING GRAPHS, PRESENTING INFORMATION ON INTERACTIONS BETWEEN WILDLIFE AND AIRCRAFT**
- **T.C. BIRD/WILDLIFE STRIKE REPORT (HARD & ELECTRONIC COPY)**
- **ECOLOGICAL STUDY, RISK ANALYSIS, AND WILDLIFE CONTROL MANAGEMENT PLAN (HARD COPY OF ELECTRONIC COPY FOR T.C.)**
- **WILDLIFE CONTROL ACTIONS TAKEN BY OPERATORS OF THE DESIGNATED AERODROME**
- **MIGRATORY PATTERNS FOR SPECIFIED TIME OF YEAR AND SPECIES**
- **EXPORT FILE FROM AIRPORT TO T.C.**

II) AUDIT TOOL

DATA

- **PROVIDES AUDIT QUESTIONS FOR INSPECTION OF THE "MANAGEMENT FUNCTIONS RELATED TO WILDLIFE HAZARDS ON OR IN THE VICINITY OF AERODROMES"**
- **PROVIDES CHECKLIST FOR ASSESSMENT OF COMPLIANCE WITH PERTINENT LEGISLATION, IF REQUIRED**
- **ALLOWS USER TO ENTER THEIR OWN AUDIT QUESTIONS**
- **USERS CAN EITHER SELECT A BRIEF RESPONSE, E.G. NON COMPLIANCE, OR INPUT DETAILED FINDINGS**
- **USERS CAN ALSO INCLUDE RECOMMENDATIONS WHICH ARE LINKED TO CALENDER**

II) AUDIT TOOL - CONTINUED

REPORTS

- **PROVIDES CHECKLIST TO BE USED DURING INSPECTIONS**
- **PROVIDE AUDIT REPORT: COVER PAGE, INTRODUCTION, AUDIT QUESTIONS, RESPONSES, REFERENCE FOR AUDIT QUESTION, NAME OF AUDITOR AND, IF REQUIRED, PROPOSED RECOMMENDATION**
- **CAN PREPARE HISTOGRAM OF MULTIPLE AUDITS AND ALLOW ON-LINE QUERY OF FINDINGS**

III) INTERACTIVE TRAINING SYSTEM

**PROPOSE INTERACTIVE CD ROM TRAINING PROGRAM
BEDEVELOPEDD WHICH ADDRESSES TRAINING PROGRAM
DESCRIBED IN TABLE 6 OF PROPOSED REGULATION - I.E.
FOR WILDLIFE CONTROL OFFICERS.**

PROGRAM WOULD ALSO INCLUDE:

- **ON-LINE MATCHING EXERCISES TO INCREASE
RETENTION**
- **EXAMPLES OF CORRECT AND INCORRECT CONTROLS,
WITHHUMORR BEING PROVIDED WITH THE LATTER
TO INCREASE RETENTION**
- **A QUICK AT THE END OF THE TRAINING SESSION TO
ENSURE THAT USERS**

APPENDIX 14

Innovations to Support Wildlife Management Planning at Airports

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Innovations to Support Wildlife Management Planning at Airports

Introduction

Airport authorities' possible liability for damages resulting from bird hazards has raised the requirement for increasing diligence in wildlife management planning processes. As well, budgetary concerns are driving the need for cost-effective risk reduction programs. Experience in the environmental field has shown that the implementation of preventive measures, resulting from a process of continuous improvement, provides the best value for risk reduction over the long term. Airfield wildlife management programs are well suited to this approach as wildlife experts advise that the most effective technique to reduce bird use of airfields is to modify habitats (Belant, 1997), a long-term preventive measure.

Preventive management has been developed and used extensively in the application of Integrated Pest Management (IPM) and airfield safety planners can take advantage of lessons learned by IPM practitioners over the past twenty years. In the Department of National Defence, IPM planners have adopted the principles of Environmental Management Systems (EMS) to address issues of liability, risk communication and continuous improvement. An EMS approach can equally be applied to Bird Strike Prevention Planning.

Technology transfer was often identified as a major obstacle in the implementation of IPM programs. Experience in the Department of National Defence indicates that Information Technology (IT) can provide very effective tools for developing and using planning and decision-making skills.

Integrated Pest Management (IPM)

Since Rachel Carson published her watershed work, *Silent Spring*, in 1962 awareness of environmental and human health concerns has continued to increase and concerns for legal liabilities have risen. In response, Integrated Pest Management has become the central policy and procedural concept for pest management activities in government, regulatory agencies and private industry. The US Armed Forces Pest Management Board defines IPM as: "a planned program incorporating education, continuous monitoring, record-keeping, and communication to prevent pests from causing unacceptable damage to operations, people, property, material or the environment. IPM uses targeted, sustainable methods, including habitat modification, biological control, mechanical control, genetic control, cultural control, mechanical control, regulatory control and when necessary, the judicious use of least-hazardous pesticides"¹.

¹ U.S. Department of Defense. 1997. DoD Pest Management Training and Certification. DoD 4150-7-M. U.S. Department of Commerce. Springfield, Virginia.

The similarity of IPM and airfield wildlife management is made more evident when the basic components of an IPM approach are reviewed:

- pest identification;
- source and cause of pests, biology and ecology of pests;
- monitoring of pest populations and development of threshold levels;
- consideration of management options;
- implementation of short term pest specific and long term preventive strategies
- record keeping and assessment
- communication

This approach is very similar to measures described in Transport Canada Airport Wildlife Management Plans². Within the IPM framework, the implementation of preventive measures is a process of continual improvement and is introduced coincidentally with ongoing pest specific strategies, monitoring and assessment. This ensures that threshold limits are being met while preventive measures take effect. However, measures proposed against single pest species must fit into the whole management system and not interfere with other interests, nor cause new problems. The development of IPM has seen significant increase in support for research and development of preventive strategies. One may expect similar trends for bird strike prevention planning.

Environmental Management Systems (EMS)

While IPM provides a technical context for pest management, an EMS addresses broader management concerns for due diligence, planning and communication. The ISO 14000 Environmental Management System (EMS) was chosen as the planning vehicle to oversee implementation of IPM practices on National Defence properties. It provided an internationally recognized, systematic approach to incorporating environmental and health and safety considerations into the organization's pest management activities and decision-making processes, and a framework for tracking, evaluating and communicating performance.

The EMS was entitled Base IPM Plan and consists of five major elements:

- commitment and policy
- planning
- implementation
- measurement and evaluation
- review and improvement

The EMS helps to insure that major environmental risks and liabilities are properly identified, minimized and managed. It identifies resources for developing, implementing, achieving, reviewing and maintaining the pest management program. It is a dynamic process, built on the

² Transport Canada. 1996. Wildlife Management Plan Victoria International Airport. Report No. 50142.

principle of continual improvement, which is consistent with the goals of integrated pest management and sustainability.

The Base IPM Plan provides guidance to the organization and promotes compliance with applicable legislation and procedures, instills positive environmental responsibility and values, and assigns accountability throughout all levels of management. It also provides a basis for risk communication, both internally and externally.

More specifically, National Defence incorporated an EMS management process in its Integrated Pest Management framework for the following reasons:

1. **Demonstration of Due Diligence:** with the current direction that is being taken by government, an internationally recognized system demonstrating due diligence may help to limit management liability.
2. **Increasing Potential Liabilities:** The potential for fines and lawsuits is escalating and the need for a compliance management system is becoming more critical.
3. **Corporate Requirement:** The federal government has made a commitment to meet EMS standards and consistent planning processes will assist in roll up of information to demonstrate departmental conformance.
4. **Public Pressure:** environmental legislation is allowing for more public input into business planning and operation. Increasing public sophistication is requiring both better corporate environmental management, and communication of this management.
5. **Cost Control:** At the same time that safety, health and environmental laws are undergoing faster change – organizational funds and resources to comply with these are shrinking. There is increased pressure to find long term cost-effective solutions.
6. **Education and Awareness:** The implementation of a new system is an excellent time for staff and management to update their knowledge.
7. **Policy Commitment:** The decision by management to implement an EMS sends a clear signal to managers and employees that these issues are being taken very seriously.
8. **Resource Commitment:** The EMS identifies resources for developing, implementing, achieving, reviewing and maintaining the organization's pest management goals.

Electronic Performance Support Systems (EPSS)

The importance of computers as a tool for the development of skills and the transfer of knowledge is now well established in both academic and commercial organizations. An EPSS is a computer-based program that is capable of acting as both a job performance aid and an online tutor. It provides a very powerful tool for technology transfer, particularly in situations of limited resources and scope of expertise, such as the smaller airport authorities. In fact, all airport authorities are affected by the ever-increasing rate of change of policies and law, which is occurring at the same time that resources are being reduced. These conflicting pressures require innovative solutions to ensure compliance and due diligence. Information Technology provides some useful tools for meeting these requirements.

To assist bases in achieving IPM sustainability targets, DND has developed an electronic performance support system that can provide significant efficiencies in training and in technical

support. The DND Base IPM Plan template was developed in 1996 in response to the department's commitment to establish IPM plans at all its bases by the year 2000. The template provides a consistently applied standard to pesticide risk reduction programs at DND properties. Supported by other electronic technology, such as the DND IPM CD ROM which provides for pest specific management strategies, the IPM template is a job performance aid that is accessible and cost-effective. It facilitates learning and training as a job or task is actually being performed. The template incorporates management planning, word processing, report preparation, subject matter prompts, reference materials and decision and record keeping aids. The EPSS will be used to provide up-to-date information in policy, law and technology and there are plans to expand the tool to permit on-line information exchange.

Conclusion

The potential for fines and lawsuits is escalating and the need for management systems meeting due diligence requirements is becoming more critical. The ISO 14000 EMS provides an internationally recognized system that can be adapted to any level of management and rolled into planning processes at all levels of management. While the EMS is not intended to address, and does not include requirements for aspects of health and safety management, it is very adaptable to the integration of such management system elements. The ISO 14000 EMS provides a flexible and comprehensive approach for wildlife management planning at airports.

Preventive measures are the key to cost-effective, sustainable risk reduction strategies. As is the case with integrated pest management, research and development of preventive technologies are an essential element of continuous improvement and the development of integrated strategies. Furthermore, local authorities and responsibility offices must have access to management techniques and problem solving strategies. Information technology is an essential tool for this purpose.

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APPENDIX 15

Soil Enrichment Systems Inc.



SESI

Soil Enrichment Systems Inc.

Restoration Technologies for Ecosystems Under Stress

BREW, AN ECONOMICALLY VIABLE ALTERNATIVE FOR WASTEWATER TREATMENT

by

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BREW, AN ECONOMICALLY VIABLE ALTERNATIVE FOR WASTEWATER TREATMENT

1. INTRODUCTION

There is a large and growing need to treat municipal, industrial, agricultural wastewaters, especially those which are more difficult to handle because of their natures (saline, highly contaminated, high or low pH, non-point source, etc.), but conventional (mechanical) treatment facilities are expensive and capital is in short supply. Natural treatment systems such as constructed wetlands are more economic to build and operate, and there is an increasing move to consider them instead.

Constructed wetlands provide excellent removals of biochemical oxygen demand (BOD), suspended solids, heavy metals, organics, and pathogens from wastewaters being treated in them (>70 - 90%+). However, although they are widely used in cold climates, winter operability sometimes presents problems and treatment wetlands only remove part of the nutrients (nitrogen and phosphorus compounds) from wastewaters (with reductions averaging only in the 50% range).

Two kinds of constructed wetlands are normally used for wastewater treatment: *free water surface* (FWS) ones in which the water flows over the surface, and *sub-surface flow* (SSF) ones in which the water flows underground in submerged beds. Although the latter operate better in cold weather and are much more efficient at pollutant removal, they are more costly.

A new sub-surface flow (SSF) wetlands technology called **BioReactor Engineered Wetland for wastewater treatment (BREW)** has now been developed by a local ecological engineering company which overcomes many of the limitations of SSF wetlands and will allow them to be more economic to build and use. BREW is an advanced constructed wetlands treatment environmental/biological technology (*ecotechnology*) which permits year-round operation at enhanced secondary treatment levels (i.e., including with high nitrogen and phosphorus removals), even for otherwise difficult-to-treat wastewaters.

This paper describes the BREW ecotechnology, its technical and economic advantages over current conventional and wetland wastewater treatment technologies, and an ongoing BREW project here in Ontario.

2. WETLANDS

Wetlands are lands which are seasonally or permanently inundated by shallow water. In natural wetlands, the presence of abundant water has caused the formation of *hydric* soils (those which are saturated with water and are anaerobic in nature) and has favored the dominance of either hydrophytic or water-tolerant vegetation.

The ecological functions of wetlands include the control and storage of surface water (and/or the discharge of groundwater); providing corridors for wildlife movement; protecting shorelines from erosion; supporting complex food chains; providing habitat; aiding in flood control and conveyance; trapping sediments; and interacting with dissolved and suspended materials in the water in manners which maintain and improve water quality.

It is these latter attributes which interest ecological engineers and have led to their widespread and growing use in pollution control. They can remove or convert large quantities of pollutants which enter them in leachates, wastewaters from cities, towns and industries, or surface runoff from non-point pollution sources (e.g., mines, agricultural areas, urban streets). The impacts of these discharges on wetlands has been highly variable, but in general they have functioned well as pollution removal mechanisms.

Wetlands are being used to remove a variety of contaminants, including biological oxygen demand (BOD) nutrients (nitrogen and phosphorus compounds), undesirable micro-organisms, most suspended and many dissolved solids, heavy metals, oil & grease, and other organic compounds. Wetland vegetation absorbs and assimilates nutrients from water. Aquatic plants in wetlands also release oxygen as a by-product of their growth, increasing dissolved oxygen content in the water and the soil in the vicinity of plant roots, thereby allowing aerobic microbial reactions to supplement the anaerobic ones normal in hydric soils. Accordingly, wetlands can be used to economically treat many kinds of waterborne contaminants.

3. WETLAND WASTEWATER TREATMENT SYSTEMS

While natural wetlands can be used for treating wastewaters, especially if they already exist convenient to a wastewater source, generally artificial, constructed wetlands are used. Constructed wetlands usually consist of a number of individual rectangular or irregularly-shaped cells filled with wetland vegetation and connected in series or parallel in one or more trains (flow streams). Wetland cells are surrounded by earthen berms and contain structures (distributors, weirs, piping) to ensure good hydraulic dispersion, control and collection. With constructed wetlands, hydrological conditions, vegetation specifically chosen for effectiveness with certain contaminants, and soil substrates engineered for various purposes can be selected to design a system which is highly effective for pollution control.

While the deliberate use of natural wetlands to treat municipal sewage began early in this century, research on constructed wetland technology only commenced at the Max Planck Institute in Germany in the early 1950s. By the 1970s, active R&D was underway at several U.S. universities and the first pilot constructed wetland unit in North America was built at the Brookhaven Institute in 1973. This was followed later that year by a full scale facility treating municipal wastewater in California. From these beginnings, the technology has evolved rapidly and ecological engineers are now able to design wetland and other natural treatment systems with as much confidence as to their operability and pollutant removal levels as with comparable conventional systems.

Canada, in particular Ontario, pioneered the use of constructed wetlands for pollution control in cold climates. During the 1980s, the Ontario Ministry of the Environment carried out seminal research on constructed wetlands handling municipal sewage at pilot facilities at Listowell and Cobalt, Ontario. There are now constructed wetlands in all provinces and territories of the country from the mouth of the MacKenzie River in the Arctic to southern Ontario.

Constructed wetlands for pollution control of the free water surface type (sometimes called *surface flow wetlands*) are marsh type ones where water flows in the open over the surface and visible surface water surrounds emergent vegetation. (There are sometimes pond-like open water areas with submergent vegetation as well.) In FWS wetlands, the submerged portions of the wetland plants as well as soil and detritus act as substrates for micro-organisms and these are responsible for much of the pollution removal. FWS wetlands are used for stormwater, municipal, agricultural and industrial wastewater treatment, both at a secondary level and, more commonly, for polishing or tertiary treatment.

There are many hundreds of FWS wetland treatment systems operating in Canada, the United States and elsewhere. Flows range from about 50 m³/d up to almost 100,000 m³/d, with about 70% having influent flows of less than 4000 m³/d. The largest operating FWS system is one of 1800 hectares in area at Kis-Balaton, Hungary, and one is planned¹ for Egypt with an influent rate in the one million m³/d range.

In sub-surface flow constructed wetlands the wastewater flows under the surface in porous media (substrates) from which wetland vegetation grows. Often this vegetation is reeds (*Phragmites* sp.) and for this reason they are sometimes also referred to as *Reed Bed* wetlands. With them, pollutant removal occurs under the surface in the substrate and vegetation root systems, and, although dense wetland vegetation is apparent in them, their surfaces are usually dry. Generally, SSF wetlands consist of one or more horizontal beds of rock, gravel, sand, or *engineered growth substrates* (artificial materials designed with specific flow, porosity and/or chemical properties). Beds in SSF wetlands can be easily replaced if clogging occurs but in most cases this would not be expected to occur for decades.

There are several hundred SSF wetland wastewater treatment systems operating in Europe (where they are usually used for secondary wastewater treatment), and hundreds there in Canada and the U.S.². Flow rates range from 4 - 14,000 m³/d, with 90% operating below 3800 m³/d. In Europe, SSF wetlands are regularly used for secondary municipal wastewater treatment, but here in North America they (and FWS ones) are usually used in polishing (tertiary treatment) service.

SSF wetlands come in two versions: those involving horizontal wastewater flow through the substrate, and those involving vertical flow where the wastewater is applied on the surface and then sinks into the bed to flow horizontally. In addition to SSF wetlands used to treat wastewaters, there are over a hundred vertical flow SSF wetland systems in Europe and over 50 in North America¹ used to dewater and condition raw municipal and industrial sewage sludges.

SSF systems provide better treatment for a given wetland surface area (up to over five times higher treatment efficiencies), but they are generally more costly to construct (two to seven times as much) than a FWS wetland of equivalent size. In addition to superior treatment efficiencies, SSF wetlands have better cold weather operating capabilities. The decision to use one type or the other now depends on project specific factors, with a tendency to prefer FWS ones where economic considerations are paramount.

If SSF wetlands could be designed with thicker substrates, even higher efficiencies would be possible and their economic disadvantages in many services might be overcome. However, maximum practical plant root depths normally limit the thickness of SSF substrates (as the plants "pump" the oxygen needed for critical wetland microbial transformations of pollutants in wastewater to their root systems).

The ultimate in constructed wetlands is the *engineered wetland*. With this more sophisticated type of constructed wetland, the wetland is treated as a field scale bioreactor, and physical, chemical and biological parameters in it are continuously monitored, manipulated, and controlled in it. Engineered wetlands may be of either FWS or SSF design.

¹ Reed, S., Crites, R., and Middlebrooks, E., *Natural Systems for Waste Management and Pollution Control*, Second Edition, McGraw-Hill, 1995.

4. ECONOMICS OF WETLAND WASTEWATER TREATMENT SYSTEMS

In general, as is shown in the following table, any comparison of natural (e.g., wetland) and conventional wastewater treatment systems, revolves around the fact that the former are land intensive and the latter are energy intensive.

TABLE 1
COMPARISON OF NATURAL AND CONVENTIONAL WASTEWATER TREATMENT SYSTEMS

	<u>Natural Systems</u>	<u>Conventional Systems</u>
"Intensiveness"	Land	Energy
Energy Source	Renewable	Non-renewable
Major Inputs	Solar Energy Soils & Substrates Vegetation, other Biomass Microorganisms	Fossil Fuel Energy Electricity Chemicals Aeration Air
Structures	Largely Earthen	Concrete, Steel, Plastic
Operation	Simple	Complex
Susceptibility to Hydraulic Shock	Low	Often High
Susceptibility to Chemical Shock	Lower	Higher
Residue Production	None	Sludge

Natural systems such as wetlands do require some non-renewable inputs for pumps and structures but their amounts are very low in comparison to those of conventional wastewater treatment systems.

Ordinary free water surface constructed wetlands have capital costs in the order of \$20K to 150K per hectare of wetland surface area², plus the cost of land. Other than land, the largest part of the capital cost is due to earthworks (site preparation, excavating of wetland cells and flow channels, berm construction, the preparation of hydric soil, etc.). As mentioned, sub-surface flow wetlands cost more than FWS ones, ranging from \$150K to over \$400K/ha, and this is due to their higher design & engineering costs plus the cost of their more expensive substrate materials³. Engineered wetlands cost more than their passive analogues, due the addition of more complicated flow control and instrumentation, but this may be offset by more efficient operation (and hence smaller sizes and costs for given levels of pollutant reduction).

² R. Kadlec & R. Knight, *Treatment Wetlands*, Lewis Publishers, Boca Raton, FL, 1996.

³ Knight, R., *Operating Experience with Constructed Wetlands for Wastewater Treatment*, *Tappi*, 76(1), 100, 1993.

Generally, both conventional wastewater treatment plants and constructed wetlands are built as parts of more comprehensive systems. For example, consider the following example of the estimated systems costs involved where a raw municipal wastewater (BOD and TSS: 200 mg/L, total phosphorus: 10 mg/L, total nitrogen: 40 mg/L, ammonia nitrogen: 35 mg/L) with an average flow rate of 1000 m³/d is treated to an advanced secondary effluent quality of 15 mg/L of BOD and TSS, 7 mg/L of total nitrogen, less than 5 mg/L of ammonia nitrogen and 0.5 mg/L of phosphorus. A conventional wastewater treatment system option (primary treatment with phosphorus removal by alum addition, activated sludge secondary treatment, biological nitrogen removal, sludge handling, disinfection) can be compared⁴ with two wetland treatment systems (FWS and SSF ones), where continuous flow facultative lagoons⁵ (with alum addition) are followed by polishing in FWS and SSF constructed wetlands⁶:

TABLE 2
COMPARISON OF NATURAL AND CONVENTIONAL WASTEWATER TREATMENT SYSTEMS COSTS

	<u>Natural Systems</u>		<u>Conventional System</u>
	<u>LAGOON + FWS</u>	<u>LAGOON - SSF</u>	
Facility Treatment Areas			
- Plant	-	-	1 - 2 ha
- Lagoon	9.1 ha	9.1 ha	-
- Wetland	<u>5.4 ha</u>	<u>2.9 ha</u>	-
- Total	14.5 ha	12.0 ha	1 - 2 ha
Wetland Trains/Cells	3/12	2/6	n/a
Capital Costs (\$K)	1,252	1,658	2,500
% of Conv. Capital Cost	52%	69%	100%
O&M Costs (\$K/year)	143	143	220
% of Conv. O&M Cost	65%	65%	100%

These numbers are indicative. Roughly, the capital cost of most wetland treatment systems will range anywhere from 50 to 95% of that for comparable conventional wastewater treatment systems treating the same volumes of wastewater to similar contaminant removal levels.

Operating and maintenance costs involve such areas as vegetation maintenance (i.e., periodic grass cutting on berms), control structure repairs, and system monitoring. O&M costs for constructed wetlands are relatively low compared to those of conventional wastewater treatment systems. They range from about 5 to 40% for the wetlands alone, more when the costs of associated processes are considered, but still much less than those for conventional wastewater treatment systems.

⁴ *Technologies For Small Water And Wastewater Systems*, Edward J. Martin & Edward T. Martin, Van Nostrand Reinhold, NY, 1991.

⁵ *Alternative Approaches For Upgrading Effluent Quality For Lagoon-Based Systems*, Technical Report FIR 2238, Canadian Council of Environment Ministers, Environment Canada and the Ontario Ministry of Environment, January, 1993.

⁶ *SESI Estimates*. All costs are adjusted to an October, 1997 Canadian dollars basis using Engineering News Record Construction Cost Index factors. The constructed wetlands are sized for winter operation (5 °C) and are also followed by chlorine disinfection.

Constructed wetland O&M values can range from a few thousand dollars per year to over \$100K/year, depending on size. The Water Environment Federation (formerly the Water Pollution Control Federation) estimates⁷ constructed wetland O&M costs to be in the order of US \$0.03 to \$0.09/m² of wetland surface. (O&M costs for wetland treatment systems will be higher due to the contributions of the other parts of the systems.) Engineered wetlands, which often involve more pumping energy, have somewhat higher O&M costs than their more passive analogues.

One way to obtain a proper comparison of the relative economic worth of two types of systems is to carry out a total net present value (NPV) calculation. This sums the time value of money over some discount period taking into account capital repayment, interest costs and ongoing O&M charges. This method has two problems when trying to make a valid comparison of the NPVs of conventional and wetland wastewater treatment systems.

The first problem is that it is common practice in NPV calculations to assign no value for a facility's equipment at the end of its useful project life (generally about 20 years). This is appropriate for mechanical systems where the equipment, buildings, etc. will be worn out (and often obsolete) by this time, but it has little meaning for wetland systems where the "equipment" (berms, structures, etc.) will largely be still useful (but also of little salvage value) after this period.

The greatest part of a wetland system's value is the value of the land it rests on, and this may hold its value or actually appreciate after 20 years. (So will the land on which a conventional wastewater treatment plant sits, but its extent will be very much less and the higher cost for demolishing and removing the old treatment equipment on it will have to be balanced against its much smaller residual value.)

One could compare land-free NPVs for the two types of systems, and this is sometimes done. However, doing so may be misleading and give conventional systems an undeserved advantage.

The second problem is the discount period itself. A 20 year life expectancy is appropriate for conventional wastewater treatment systems, but what is appropriate for wetland systems? Certainly an operating system life of very much more than 20 years is called for, although the first modern constructed wetland systems only came into operation in the mid 1970s and most have not operated that long. However, experience with natural wetlands used for wastewater treatment indicates that they continue to operate well far beyond 20 years.

Two American systems², Great Meadows Marsh on the Concord River, Mass. and Brillion Marsh in Wisconsin have operated for over 70 years and have been shown to retain their treatment efficiencies³. Thus, using a 20 year NPV (which is what is generally used for conventional systems) is biased against wetland systems, but using a 20 year NPV for conventional systems and longer ones (say 50 years or more) for wetland systems leads to 'apples and oranges' comparisons.

Wetlands are not panaceas for wastewater treatment. They have many advantages but they also have disadvantages. They require a lot more land (even engineered ones), and soils, topography and wastewater must be appropriate in order to consider them. All that can be said with certainty about their relative economics as compared to conventional wastewater treatment systems is that they cost somewhat less to build, very much less to operate, and that their life cycle costs are much less, as is indicated qualitatively in the table on the following page.

⁷ *Natural Systems for Wastewater Treatment, Manual of Practice, WPCF Publication FD-16, 1990.*

TABLE 3
COMPARISON OF NATURAL AND CONVENTIONAL WASTEWATER TREATMENT SYSTEMS COSTS

	<u>Natural Systems</u>	<u>Conventional Systems</u>
Land Requirements/Cost	Higher	Lower
Monitoring Costs	Comparable	Comparable
Cost of Residue Disposal	None	Can Be High
Pumping Costs	Low	Can Be High
Chemicals Costs	Usually Low or None	Can Be High
Capital Costs	Lower	Higher
O&M Costs	Much Lower	Much Higher
Life Cycle Costs	Lower	Higher

5. COMPARISON OF FWS AND SSF WETLANDS

One way to design constructed wetlands (and many other types of wastewater treatment systems) is by considering them to be plug flow reactors⁸ in which linear first order reaction kinetics are extant. A constructed wetland can be sized using the following equation:

$$C/C_i = \exp(-kA/Q)$$

Where C is the concentration of a pollutant, i represents the inlet, A is the wetland surface area, Q the wastewater flow rate, and k the first order areal rate constant. The values of the rate constant, k, can be obtained from performance data from actual operating wetland systems.

Solutions to the above equation for the size (area) of a wetland needed to obtain a desired pollutant reduction level can be determined using published^{1,2} values of k, known flow rates and inlet concentrations of a pollutant and target (desired) outlet concentrations. Wetland sizings can be carried out for desired levels of reductions at a particular temperature for any of: biological oxygen demand (BOD), suspended solids (TSS), ammonia nitrogen (NH₄-N), organic nitrogen (Org-N), nitrate nitrogen (NO₃-N), total phosphorus (TP), pathogens (fecal coliforms or FC) or other contaminants.

⁸ Ecological engineers recognize that constructed wetland performance is not exactly modelled by plug flow, but in general it is much closer to plug flow than the alternative continuous mix model.

Wetlands are sized by solving the above equation for each of the contaminants of interest. (Solving for nitrogen compounds requires iteration as they can convert one to another.) Whichever of the calculations yields the largest area, this result shows that the reduction of that pollutant in the system is deemed to be controlling and it will be the one on which more detailed design later will be based². (In many wastewater treatment systems, this turns out to be phosphorus or ammonia nitrogen.)

The values of the rate constants (k) are different for FWS and SSF wetlands, with higher values being found for the latter, indicating that SSF wetlands provide better treatment for a given surface area. The reason is not hard to see. Treatment wetlands can be viewed as slow rate attached growth systems. The area available for microbial attachment in SSF ones varies with the volume of the wetted substrate (a three dimensional matrix), while that in FWS wetlands varies with the surface of the sediment, plants, and detritus (roughly a two dimensional area, albeit a highly folded one).

As mentioned, a SSF wetland is generally more costly to construct than a FWS wetland of equivalent size. This may be compensated for by the better SSF treatment efficiency (higher k values) and better cold weather operating capability. The decision to use one or the other will depend on project specific factors. Obviously, where gravel for substrate is available at a site, the cost of a SSF wetland will be much less than it would be for a situation where it had to be transported to the site at some expense. The following table² compares rate constants and average construction costs for the two types for operation at 20 °C.

TABLE 4
RATE AND COST COMPARISONS FOR FWS AND SSF WETLANDS

	TSS	BOD	TP	NH ₄ -N	Org-N	NO ₃ -N	FC
FWS k value, m/yr	>1000	34	12	18	17	35	75
SSF k value, m/yr	>1000	180	12	34	35	50	95
SSF k/FWS k	-1.00	5.29	1.00	1.89	2.06	1.43	1.27
SSF cost/FWS cost	7.14	1.37	7.14	3.85	3.57	5.00	5.88

Perusal of Table 1 indicates that, in general, all other things being equal (and they usually are not), where the reduction of suspended solids or phosphorus is controlling, selection of the less costly FWS variety (less than one-seventh as much as the SSF alternative) will be indicated. This is probably because the dominant pollutant reduction processes are not biological ones, but instead are settling/filtration (gravitational/inertial) and adsorption (geochemical) for the TSS (suspended solids) and TP (total phosphorus) cases respectively. The same may be true for pathogens removal (FC), where, on average, a SSF wetland would cost almost six times as much to achieve the same removal levels, while the increase in efficiency which a SSF provides is less than 30%.

Where the reduction of BOD is controlling, selection of the more costly SSF variety might be indicated, as the difference in cost is not that great (on average, a SSF wetland will cost only 37% more than that of a FWS one), but the advantage in treatment efficiency is very large (over 5 times).

Where one or other of the nitrogen compounds are controlling, approximately doubling the treatment efficiency would not normally seem to justify SSF wetland costs which, on average, are 3 1/2 to 5 times as much.

It might be imagined that the balance could be tipped in favor of SSF wetlands by increasing the thickness of the substrate. As a three dimensional system (the substrate) is involved with SSF wetlands, this should dramatically increase the value of k for attached growth-dominated contaminant reductions (those for BOD and the nitrogen compounds). However, some of the major microbial transformations (and attached growth processes are such) are aerobic in nature and depend on wetland vegetation to provide oxygen to the microbes in the plants' root zones. This limits substrate thickness in ordinary constructed SSF wetlands to the 0.4 to 0.7 m range, the maximum practical root penetration depth that the wetland plants normally used can manage.

Nevertheless, if a method could be found to allow thicker SSF substrates, the situation might be quite different.

6. ECOTECHNOLOGIES

The engineering of constructed wetlands belongs to a new environmental business area which has recently begun to take shape. The ecological engineering⁹ sector bridges the fields of ecology and engineering and involves the design, monitoring, restoration and creation of ecosystems using both conventional products and technologies and new special ones known as *ecotechnologies*. Ecotechnologies are those biologically-based technologies used to enhance natural methods in the remediation, restoration, manipulation or creation of ecosystems.

Ecotechnology is not just another name for biotechnology. It is more than that. Ecotechnology intimately involves not just an environmental focus, but also environmental values and the principles of *sustainable development*.

The following table illustrates the differences between ecotechnology and biotechnology.

TABLE 5
COMPARISON OF ECOTECHNOLOGY AND BIOTECHNOLOGY

CHARACTERISTIC	ECOTECHNOLOGY	BIOTECHNOLOGY
Basic Unit	ecosystem	cell
Basic Principles	ecology	genetics; cell biology
Control	forcing functions, organisms	genetic structure
Design	self-design with some human help	human design
Biotic Diversity	protected, enhanced	changed
Costs	reasonable	enormous
Energy Basis	solar based	fossil fuel based

Ecotechnologies by definition are interactive and holistic. Their use implies not only a shift to biologically based systems approaches but also a shift to decision making that is also ecosystem-based.

⁹ *Ecological Engineering, Wave of the Future*, James Higgins, Remtech Conference, Toronto, Ontario, January, 1997.

Ecotechnologies are used in all parts of the environmental field but find particular use in ecological engineering, wastewater treatment, composting, soil bioremediation, land management and some types of hazardous waste treatment. The use of ecotechnologies in wastewater treatment is ancient but it is only recently that their use in other parts of the environmental industry has become more widespread, often through the use of integrated systems approaches.

Soil Enrichment Systems Inc. (SESI) is a Canadian ecological engineering company which specializes the restoration, remediation and creation of terrestrial, wetland and other aquatic ecosystems, especially those which are or will be subjected to stress due to human activities. The company has developed superior capabilities and advanced, innovative 'ecotechnologies' in the rapidly emerging area where the biotechnology and environmental fields overlap.

SESI has developed several highly innovative ecotechnologies, including:

- SDS (Sub-Surface Dispersal System for Soil Aeration)
- PROPASYS™ (Rapid Vegetation Establishment System)
- ENGINEERED SOIL (Engineered Growth Substrates)
- LIVING WEB (Reinforced Native Vegetation Ground Cover)

These ecotechnologies are systems integrated bioreactor ones, and most are available as families of products in that there are several varieties of them. (In addition, each variety may come in various formulations.) For example, PROPASYS™ comes in turfgrass, wet and dry meadow, woodland and wetland varieties to name just a few.

The development of each ecotechnology led to the later development of other ones, even as the original ones continued to evolve and improve. For example, the SDS ecotechnology led to the development of ENGINEERED SOIL, which in turn led to the development of PROPASYS™, LIVING WEB evolved from PROPASYS™.

While SESI's background in soils and vegetation is useful in the design and construction of pond and FWS wetlands, its ENGINEERED SOIL and PROPASYS™ experiences gave it a particular orientation to the more technologically complex and challenging SSF wetlands which depend on substrates of the kind with which the company works all the time. Similarly, the availability of wetlands PROPASYS™ formulations led quickly to their use in field wetlands construction projects being carried out by the company.

As mentioned, in wetlands engineering, achieving high levels of removal of nitrogen and phosphorus contaminants in wastewaters is particularly challenging. In the case of phosphorus, while plants do take it up from wastewater easily, most of that which is metabolized is later desorbed during senescence. The only long term "sinks" for it in a wetland involve burial in sediment or adsorption on surfaces. However, the gravel substrates usually used with SSF wetlands have little capability for much physical or chemical adsorption of phosphorus on the gravel particle surfaces.

It has been noticed¹⁰ in pilot SSF constructed wetland experiments that where other types of SSF wetland substrates (e.g., shales) have been used which had chemical properties (e.g., clay components, the presence of certain metal oxides), phosphorus adsorption was higher and seemed to involve more or less permanent chemical adsorption on the surfaces of the substrate particles. SESI's work with the engineered substrates used in **ENGINEERED SOIL** and **PROPASYSTTM** formulations led quickly to the idea of designing or "engineering" wetland substrates with the particular properties needed to permanently adsorb species such as phosphorus.

Similarly, the use of the SDS ecotechnology to promote aerobic transformations in terrestrial soils led naturally to the idea of using it in wetland soils and substrates to promote similar aquatic aerobic transformations such as those for removing certain nitrogen contaminants.

Also, although **PROPASYSTTM** was not developed for it (it was developed with site restoration in mind), by chance it is "preadapted" for use in *phytoremediation* (the clean up of contaminated sites using a form of bioremediation which supplements microbial transformations with plant-based ones). The concept developed of bioengineering vegetation (in a wetland **PROPASYSTTM** formulation) which would take up nutrients and other contaminants from a wastewater into its tissues, from which it could be removed from the system by harvesting.

7. THE BREW CONCEPT

The combination of sub-surface flow engineered wetlands technology with SESI's existing ecotechnologies has led to a new ecotechnology called **BioReactor Engineered Wetland for wastewater treatment (BREW)**. It is one in which inlet, outlet and intermediate process conditions in a SSF wetland are continually monitored, manipulated and controlled, leading to a field scale bioreactor with sophisticated instruments, controls and computer software operating in a natural systems setting.

BREW allows for economic, year-round constructed wetland operation at enhanced secondary treatment levels (i.e., including with high nitrogen and phosphorus removals), even for the treatment of otherwise difficult-to-treat wastewaters. These include highly contaminated ones, those of high or low pH, saline ones, ones with varying levels of contamination over time, and those which are particularly difficult to treat with current technology. A Technology Profile prepared by the Ontario Centre for Environmental Technology Advancement (OCETA) is attached and describes **BREW** in more detail.

The **BREW** ecotechnology involves:

- **ENGINEERED SUB-SURFACE FLOW WETLAND CELLS**
- **BIOREACTOR OPERATION**
- **DESIGN FOR THERMAL EFFICIENCY**
- **SUPERIOR HYDRAULIC CONTROL**
- **PHOSPHORUS ADSORPTION USING ENGINEERED SUBSTRATES**
- **AERATION TO INCREASE LEVELS OF AEROBIC TRANSFORMATIONS**
- **PHYTOREMEDIATION BY VEGETATION HARVESTING**

¹⁰ E. Lemon, G. Bis, L. Rozema, and I. Smith, *The Friends of Fort George Sewage Waste Amendment Marsh Process Project (SWAMP)*, Symposium on Constructed Wetlands in Cold Climates, Design, Operation, Performance, Niagara-on-the-Lake, Ont., June, 1995.

As can be seen from the sketch in the attached OCETA profile, each BREW system consists of a set of at least three engineered wetland cells: a primary *BOD/TSS removal cell*, a secondary *aerobic transformation cell*, and a tertiary *anaerobic transformation cell*. Monitored parameters include flows, temperature, pH, electrical conductivity, redox potential, dissolved oxygen content, turbidity, TOC, and several others. Computer software measures, models and controls these parameters.

Good hydraulic control is a feature of BREW. This is achieved using engineered substrates whose physical as well as chemical properties are carefully selected. Porosities and hydraulic conductivities of the engineered substrates used in some of the cells in a BREW system are above those of the gravels and other substrates normally used in SSF wetlands. These substrates are also engineered to have superior phosphorus adsorption capabilities (thousands of tonnes per hectare of phosphorus adsorption capacity versus the few hundreds of tonnes /ha usually available with SSF wetland substrates).

Multiple lines of tubular SDS diffusion membrane (aeration tubing) are installed at the bottom of the substrates in primary (BOD/TSS removal) and secondary (nitrogen transformation) cells of BREW systems. These allow air from blowers/plant compressed air systems to be *diffused* (not pressured) into the substrates, supplementing dissolved oxygen in the wastewater and that "pumped" by the aquatic vegetation growing in it. The use of SDS allows BREW wetland cells to have thicker substrates (~ one meter or more thick vs an average of 0.6 m in ordinary SSF wetlands.)

BREW wetlands are designed to optimize thermal efficiency and ensure superior operation, even in winter. This occurs not only passively (SSF design, thicker substrates, etc.), but also actively (adding warm water with the SDS tubing, heating coils in substrates, balancing of wastewater sensible heat, etc.). Market forces are driving the development of BREW and SESI is aware of potential BREW customers who pump around large amounts of warm cooling and process waters as part of their industrial processes. They could easily and economically provide slipstreams of them to the initial cells of nearby wetland treatment systems, instead of pumping them to the top of large cooling towers, as is now often the case.

Although it is well known that, at certain times of the year, wetland plants can take up from 10-15% of a wastewater's influent nitrogen, and 40-60% of its phosphorus, (as well as fractions of some wastewater influent metal and heavy organics contaminants), the harvesting of vegetation from constructed wetlands to remove the contaminants taken up is usually impractical and/or uneconomical and is not normally carried out. However, BREW wetlands will often be used in special situations which may often prove exceptions to this rule. With them, plant harvesting and disposal may be practiced and, in addition to removing nutrients, this opens the potential of phytoremediation. In addition, the "dry" surfaces of SSF wetlands presents an opportunity for harvesting equipment access not practical with pond and FWS wetlands.

BREW wetlands are not for most treatment wetland applications. They will only be used in those situations where refractory, harder-to-treat wastewaters are involved (e.g., some industrial wastewaters), ones for which there are few or no practical alternative treatment options (e.g., AMD, food processing plant effluents, other industrial wastewaters, many leachates), and certain other special situations (e.g., certain combined wastewater/stormwater systems, waters from isolated developments currently without access to adequate treatment facilities).

8. THE BREW PILOT PROJECT IN VAUGHAN

SESI operates from a 5 ha site, located in a rural area of the Woodbridge part of Vaughan. The site has offices, an operations centre, a greenhouse, hardpan construction/equipment storage yards, refrigerated storage facilities, field vegetation test plots/areas, soil mixing and blending areas, and parking areas, as well as open fields, streams, woods and a natural wetland. The operations centre contains a shop, a warehouse, a soils laboratory and seed/vegetation propagation/ rooms and equipment, and areas where bench scale equipment is located. There was adequate room at the site for a large pilot wetland facility, the company possessed the construction equipment and proven expertise to construct one, and such a facility is now under construction. It is being used to demonstrate the BREW ecotechnology.

The demonstration involves three aspects:

- LABORATORY/GREENHOUSE TESTING
- BENCH SCALE BREW UNIT
- PILOT SCALE BREW UNITS

The project will continue for 30 months. As many of the high strength wastewaters which will be imported for the demonstration project will require pre-treatment before being routed to the pilot wetland, pilot scale pre-treatment facilities are also planned as part of the project. These include an aeration pond, a fixed film bioreactor and a peat filter. Others are being considered as well.

The sketch on the following page shows the layout of the BREW facilities.

The BREW pilot unit consists of nine cells in three sets. One set (3) of larger, BREW "Bioreactor" cells (10 m by 10 m each) is paralleled by a set (3) of similarly-sized ordinary FWS and SSF "Control" cells (i.e. passive, non-engineered ones). A second set of smaller (5 m by 5 m) BREW "Treatability" cells are located at right angles to the BREW Bioreactor and Control cells.

The 100 m² BREW cells will be used to test the bioreactor system as well as instrumentation & controls, hydraulics, hydrology, winter operations, general operability, and the removal of spiked contaminants. Well water will be used in these cells and no wastewaters will flow through them during the demonstration project. All cells are underlain with clay to prevent infiltration or exfiltration of water. Non-contaminated effluent is discharged from the large bioreactor cells to a natural wetland via an overland flow terrestrial wastewater treatment system (a vegetated filter strip).

The three smaller (25 m²) BREW Treatability cells will be used for actual wastewater tests and phytoremediation experiments. For such tests, a wastewater (e.g., leachate or AMD) will be trucked in and stored onsite in tanks until it is pumped to the Treatability cells for testing. Treated effluent from the Treatability cells will be collected after BREW treatment and pumped back to other tanks, from which it will be returned by truck to its source. No wastewater, treated or untreated, will be discharged to the environment. In addition, the Treatability cells are underlain with an impermeable plastic geotextile membrane to prevent any wastewater from exfiltrating from them.

The Vaughan BREW pilot demonstration facility will allow the large scale testing of difficult-to-treat wastewaters (leachates, AMD, food plant wastes, raw sewage, etc.) in a field setting. As well, it will further develop and refine the advanced features of the BREW system (e.g., controls, engineered substrates, bioreactor operation, substrate aeration, etc.).

9. BREW COLLABORATORS

The BREW project has generated intense interest. Current collaborators in it are OCETA, the National Research Council, the Metropolitan Toronto and Region Conservation Authority, the Works Department of Metropolitan Toronto (Metro Works), Environment Canada (two groups) and the MOE (two groups), as well as Conestoga-Rovers & Associates (CRA), Dofasco, the Altech Group and other private sector corporate interests. Five local universities (Toronto, Waterloo, Guelph, McMaster and York) have expressed interest in collaborating as well, and are evaluating graduate students who might participate as part of their post-graduate activities under NSERC and similar programs. The two pre-eminent treatment wetlands experts in the world (Sherwood Reed of Environmental Engineering Consultants and Dr. Robert Kadlec of Wetlands Management Systems, see references 2 and 3) are advisors to the BREW project.

10. BREW ECONOMICS

Just how much better than an ordinary SSF wetland a BREW will be is not known as yet and it is one of the objectives of the demonstration project to determine just how much so. It should be very much more efficient.

With a BREW cell, substrate depths can be increased to one metre or more thick (vs. the conventional limit of 0.6 - 0.7 metres, set by maximum plant root penetrations and hence oxygen supply). At least for the critical aerobic microbial transformations, efficiency (over that of ordinary SSF wetlands) should increase in proportion to the substrate volume increase but it is recognized that hydraulic and other constraints may provide a upper limit.

Conceptually, if a BREW substrate were twice as thick as that of an ordinary SSF wetland substrate and ammonia reduction, for instance, was controlling, theoretically a BREW system would be twice (and could possibly be several times) as efficient as an ordinary SSF one (or alternately, would need to only be one-half or less the size to achieve the same performance). In addition, as mentioned above, in many cases the removal of phosphorus is the size-controlling aspect of wetland design. With the use of engineered substrates in BREW designed to adsorb phosphorus, this will no longer be the case, allowing other factors requiring less area to be selected.

The following table shows the estimated sizing and costs for a BREW wastewater treatment system (a sedimentation pond and a BREW wetland) designed at twice ordinary k values to treat "raw" (i.e., primary treated) sewage of the quality mentioned in Section 4 to advanced secondary sewage treatment levels:

TABLE 6
BREW WASTEWATER TREATMENT SYSTEM COSTS

Wetland Treatment Area	2.1 hectares
Wetland Trains/Cells	2/6
Capital Costs (\$K)	1,100
% of Conv. Capital Cost	46%
O&M Costs (\$K/year)	100
% of Conv. O&M Cost	45%

The results in Table 6 can be compared with those in Table 2. Because of the nature of the engineered substrates used in BREW, the phosphorus level in the Table 6 case effluent would be negligible (<0.05 mg/L). An ordinary SSF wetland treating the same influent would require over 30 ha of surface if had to meet a <0.5 mg/L phosphorus level in the effluent. If an ordinary passive SSF wetland were used with upstream phosphorus removal using alum or ferric chloride, ammonia nitrogen removal would dictate an area of over 20 hectares (with attendant higher capital and O&M costs). Both ordinary SSF cases are uneconomic for treating primary effluent, but the BREW option is clearly the most economic.

BREW promises to provide year round wastewater treatment to advanced secondary levels in a natural systems setting with costs much less than those of either natural or conventional wastewater treatment alternatives. In addition it can be designed to readily handle those difficult-to-treat wastewaters (acid mine drainage, leachates, etc.) that currently present treatment problems at affordable costs.

The successful development of the BREW ecotechnology will lead to attractive opportunities in a niche area which is not yet served by wetlands technology. Its use will benefit the environment as a whole by being available to allow the treatment of wastewaters which either are not now being treated, or whose treatment is still inadequate. Just by being available, BREW will enhance the reputation of Canada for wetlands technology and lead to increased use of treatment wetlands of all types. Its existence will help restore Ontario and Canada to the leadership position in wetlands technology which they once possessed.



OCETA ENVIRONMENTAL TECHNOLOGY PROFILES

BREW
BIOREACTOR ENGINEERED WETLAND
FOR WASTEWATER TREATMENT
 * PILOT SCALE

CONTACT:
 SOIL ENRICHMENT SYSTEMS INC.
 10800 Weston Road
 Vaughan, Ontario, Canada L4L 1A6
 Tel. 905-832-2166 • Fax 905-832-0751

PROCESS/PRODUCT DESCRIPTION:

- biological nutrient removal
- field-scale bioreactor
- constructed wetlands
- enhanced secondary wastewater treatment

Wetland wastewater treatment systems reduce nutrients, pathogens (bacteria, viruses), organics, BOD, and suspended solids through a variety of biological, chemical and physical methods. Treatment wetlands have a variety of advantages over conventional treatment: effective and reliable wastewater treatment more economically, low energy requirements, tolerance of fluctuating chemical and hydrologic conditions, and a variety of indirect aesthetic benefits. Constructed wetlands are very effective but face limitations with winter operation and with continuously achieving high levels of nitrogen and phosphorus removal. **BREW** is a special type of con-

structed wetland called an *engineered wetland* which is operated as a field-scale bioreactor and in which physical, chemical and biological parameters are continuously monitored, manipulated and controlled. This allows **BREW** to treat very difficult-to-treat wastewaters such as leachates and acid mine drainage, year-round, to enhanced secondary treatment levels. **BREW** uses an integrated approach of biosystem management; maximizing desired growth conditions while at the same time controlling rate-limiting process factors under field conditions. **BREW** is designed for the long-term treatment of point and non-point sources where traditional treatment

methods may be impractical or uneconomical. **BREW** combines into a new system bioreactor capabilities for engineered natural systems with three proprietary biological/environmental technologies (ecotechnologies): **ENGINEERED SOIL** (engineered growth substrates), **PROPASYST™** (a rapid vegetation establishment system) and **SDS** (a subsurface dispersal system for oxygen and process inputs), along with constructed wetland design, engineering, and construction technologies. The new system overcomes many of the problems of conventional constructed wetlands, such as achieving high levels of nutrients removal in wintertime.

PROCESS/PRODUCT APPLICATION:

- landfill leachate
- acid mine drainage
- non-point sources

The **BREW** process is currently at the pilot scale while the individual components which make it up have been repeatedly proven. **SDS** has been used in irrigation, bioremediation and aeration applications. **PROPASYST™** has been used successfully in dozens of revegetation and erosion control projects. **ENGINEERED SOIL** formulations are made from waste materials and pollution control byproducts, and are used in site restoration applications. Soil Enrichment Systems Inc. (SESI) regularly designs and constructs wetlands of all sorts and has developed bioreactor technologies and terrestrial applications.

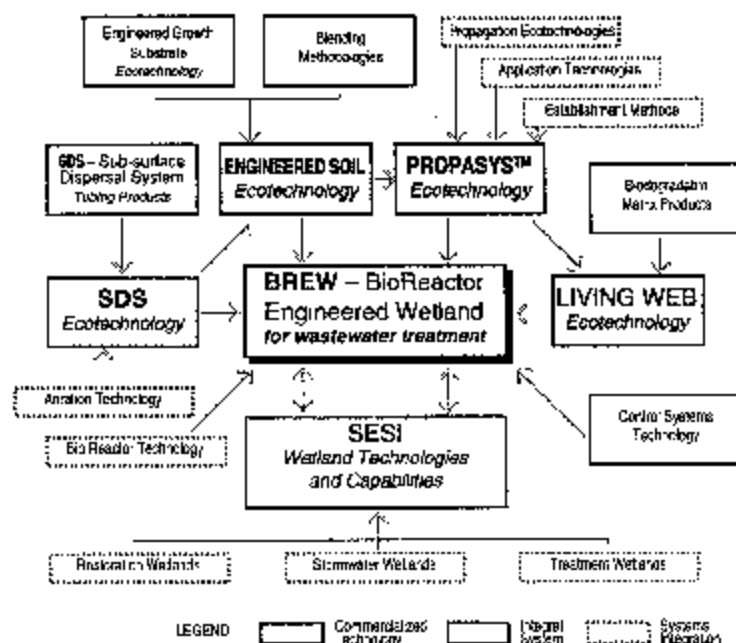


Figure 1: BREW - An Integrated Systems Technology



SESI

SOIL ENRICHMENT SYSTEMS INC.

Restoration Technologies for Stressed Ecosystems

SESI AND ITS WETLANDS ENGINEERING CAPABILITIES

Soil Enrichment Systems Inc. (SESI) is a Canadian environmental firm which focuses on the restoration, remediation, and/or creation of terrestrial, wetland and other aquatic ecosystems, especially those which have been or may be stressed by human activities. The Company provides design, consulting, engineering, product research, development and sales, and field construction services in market areas such as Bioengineering (the restoring, remediation and/or creation of ecosystems), Natural Systems for Pollution Control (treatment wetlands, lagoons), and Industrial Soil Ecology (soil bioremediation, phytoremediation). Currently, its largest areas of activity are in wetlands engineering and stream/river corridor construction projects, although phytoremediation work (using plants in site remediation) is burgeoning as well. SESI is an affiliate of Conestoga-Rovers & Associates (CRA), a major, Canadian environmental engineering consulting firm which has offices across Canada and the United States.

SESI defines itself as an ecological engineering company, one which is part of a new sector of the environmental industry which seeks to marry civil, chemical and agricultural engineering, with ecology, biology, agronomy, horticulture and other natural sciences. Ecological engineering involves the design, monitoring, restoration and even creation of terrestrial, aquatic or wetland ecosystems using both conventional products and technologies and new special ones known as ecotechnologies. These are environmental/biological technologies used to enhance natural methods in the remediation, restoration, manipulation or creation of ecosystems.

Ecological engineering firms such as SESI base their businesses on the premise of conserving and restoring both renewable and non-renewable resources by using both in partnership. Ecological engineering uses integrated approaches for conserving the natural environment while at the same time adapting to and solving intractable environmental pollution problems.

Ecological engineers use ecotechnologies, other technologies, and capabilities applied together in an integrated manner, delivered in such a way as to complement and enhance nature's own methods. They seek to (re-)design ecosystems and then manipulate/control them for the mutual benefit of society and nature. Optimizing desired biological outcomes is achieved by identifying and dealing with rate-limiting conditions.

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SESI's highly talented staff have been involved in the design and construction of numerous stormwater wetlands at Ontario locations such as Canadore College in North Bay, the Peterborough Naval Club, the Forsite Homes sub-division in Keswick, Copeland Creek in Penetanguishene, MacKenzie Glen in Maple, Armitage Pond in Alliston, Woodsmere in Pickering, Little Lake in Midland, Cootes Paradise in Hamilton and the Williamsburg subdivision in Whitby. The Company has several more stormwater wetland projects underway or recently completed, including a large (16 acres) wetland system at East Riverside in Windsor, and a large wetland system at the West Don Valley headwaters in York Region. Several more are just getting underway or are planned.

Along with CRA, SESI is working on a large (~16 acres) mitigation wetland project at a Superfund site north of Detroit and recently completed another at a Superfund site at Beacon Heights in Connecticut.

SESI is also a major player in the pollution control (treatment) wetlands area. Its specialties are integrated biosystems approaches (which combine treatment and stormwater wetlands with naturalized areas and recreational/economic activities on a site), and sub-surface flow (SSF, sometimes called reed bed) wetlands for the treatment of otherwise difficult-to-handle wastewaters such as leachates, AMD and industrial wastewaters.

SESI is currently involved in the design of a major (~15 ha) free water surface constructed wetland to treat industrial wastewater from the Terra Canada fertilizer plant at Courtright, Ontario. It is hoped that construction of this wetland will begin next year. The Company is also proposing to carry out wetlands engineering/phytoremediation/site restoration activities for ICI at Courtright. SESI is designing a wetland system for the Taro Aggregates Division of Philip Services Corp. to treat leachate from its industrial waste landfill at Stoney Creek as part of an integrated biosystems approach which will involve an 18 hole golf course, sports fields, natural areas and stormwater wetlands. It recently completed a study for Sunoco's Samia Refinery on wetland treatment options for leachate from its landfarming operations and plans to construct the treatment wetland there next year.

SESI is planning and/or carrying out several other wetland-related design and engineering projects, including ones on the treatment of industrial landfill leachate, municipal sewage, lagoon effluent, and the use of slag by-products from the Dofasco steel mills as wetland substrates. SESI's Chairman teaches a course in wetlands engineering part time at the University of Toronto. (An article by us in a recent issue of *Hazardous Waste Management* magazine describes the potential of wetlands engineering.) So far as is known, SESI is the largest designer and builder of constructed wetlands in Ontario, if not in all of Canada.

SESI is unique in that, in addition to carrying out design & engineering for pollution control wetlands, it has also carried out vegetation propagation, establishment and remediation projects, and also has developed highly innovative, relevant ecotechnologies. And, most importantly, SESI actually constructs wetland ecosystems in the field. In doing so the Company takes complete responsibility that these complex natural and artificial ecosystems will actually perform as forecast. Accordingly, SESI combines leading edge wetlands science R&D and advanced wetlands design & engineering with hands on field construction expertise. As a contractor, SESI has operated across Ontario and into Quebec and adjacent American States (New York, Michigan), and is now extending its territory. As an engineering consultant, SESI already operates across North America and worldwide.

SESI operates from a 5 ha site, located in a rural area of the Woodbridge part of Vaughan, Ontario, 25 km north of Toronto. The site has a detached farmhouse (converted into offices), a large operations centre, a 60 m² greenhouse, a one ha hardpan construction/equipment storage yard, refrigerated storage facilities, field vegetation test plots/areas, soil mixing and blending areas, and parking lots, as well as open fields, streams, woods and natural wetlands. The operations centre consists of offices, a shop, a warehouse, a soils laboratory and seed/vegetation propagation/bench scale testing room, and other facilities. The Company's field equipment includes normal agricultural machinery (tractors, spreaders, tilling equipment), construction equipment (back hoes, skid steers, loaders), landscape construction machinery (hydroseeders, trucks, planting equipment) and custom machinery for its proprietary ecotechnologies (large scale soil mixing application and establishment equipment).

As mentioned, SESI is also an R&D firm developing advanced ecotechnologies. It has developed and commercialized highly innovative field scale ecotechnologies for *sub-surface aeration* in soils (the SDS ecotechnology); *engineered growth substrates* which can be used as artificial soils (the ENGINEERED SOIL ecotechnology/family of products); *rapid vegetation establishment systems* (the PROPASYS™ ecotechnology/family of products) which can be used in site restoration and phytoremediation; and *reinforced native vegetation groundcovers* for protecting from erosion in places such as steep slopes (the LIVING WEB ecotechnology). Wet meadow, wetland and upland versions of PROPASYS™ and LIVING WEB are available.

SESI defines an *engineered wetland* as a constructed wetland in which process conditions are continually monitored, manipulated and computer-controlled, in contrast to the more passive operation of an ordinary constructed wetland. SESI is developing a proprietary sub-surface flow engineered wetlands technology which builds on its existing wetlands capabilities and its field scale bioreactor ecotechnologies. BioReactor Engineered Wetland for wastewater treatment (BREW) is one designed to achieve enhanced secondary treatment levels (including high levels of nitrogen, phosphorus and heavy metals removals) year round, especially for otherwise difficult-to-treat wastewaters such as primary sewage effluents, food plant wastewaters, AMD, and leachates from landfills. The BREW ecotechnology is one where materials and energy can be added and used to manipulate and control process conditions. It is being designed to be a field scale bioreactor involving sophisticated instruments, controls and software operating in a natural systems setting.

SESI is now constructing a large BREW pilot unit (9 cells of 675 m²) plus bench scale facilities at its site in Vaughan. The project is being financed by the National Research Council, SESI, CRA and several others. Collaborators include the MOEE, Environment Canada, the MTRCA, several universities (Toronto, McMaster, York, Guelph and Waterloo), the Ontario Centre for Environmental Technology Advancement (OCETA), the Works Department of Metropolitan Toronto, Dofasco, the Altech Group and several others.

Technologically, BREW is far more advanced than anything anyone else is developing. One of its purposes is to give Canada back the leadership in cold climate wetlands technology which the country held in the 1980s and then lost.

In addition to its wetlands experience, SESI has carried out dozens of highly related stream, riverbank and lakeshore restoration and renaturalization projects across Ontario, including ones on the East Don River in Toronto, Highland Creek in Scarborough, Tannery Creek and the East Holland River in Aurora, Bogart Creek in Newmarket, Mullett Creek in Mississauga, and Gibbons Park in London.

SESI is not restricted to just wetland wastewater treatment systems. In conjunction with its affiliate, CRA, it is able to offer any type of conventional wastewater treatment technology, including advanced nutrient removal facilities. SESI is involved with various terrestrial wastewater treatment initiatives, including those for soil infiltration and spray irrigation. The Company's vegetation, soil, renaturalization, and site restoration experience and expertise give it unmatched capabilities in designing, and constructing engineered ecosystems of all sorts.

SESI is also involved in all aspects of bioremediation, including phytoremediation. This latter area is the use of terrestrial and aquatic plants and trees for bioremediation, an emerging field. SESI is involved in several projects in this area. It has just completed a large field scale PAH phytoremediation project for a Fortune 500 company in the U.S. midwest, and is working with several petroleum refiners on phytoremediation treatability tests for landfarm soils.

The various parts of SESI's business are inter-related and many activities involve several. (I.e., a constructed wetland project may involve the placement of wet meadow and wetland PROPASYST™ blends.) Soil Enrichment Systems has developed its capabilities to a level at which it can engineer an ecosystem to almost any customer requirement. It can design a stormwater wetland system, a stress-resistant sports field of turfgrass, dry or wet meadows, a woodland, a low environmental impact golf course, or a marsh. The Company's integrated biosystems approach satisfies the needs of society and nature for the benefit of both. Its special expertise in soil science and vegetation of all sorts gives it a perspective and capability that is unmatched in ensuring that the vegetation associated with a system will be quickly and successfully established and will perform in the manner anticipated.

SESI is the leader in wetlands technology and will be delighted to make presentations on it to prospective clients.



SESI

SOIL ENRICHMENT SYSTEMS INC.

Restoration Technologies for Ecosystems under Stress

CORPORATE PROFILE

Soil Enrichment Systems Inc. (SESI) is an environmental company which has a particular focus on the creation, restoration, and/or remediation of terrestrial, wetland and aquatic ecosystems which have been or may be, stressed by human use. The Company has developed superior capabilities and advanced, innovative technologies in the rapidly emerging area where the biotechnology and environmental industries overlap. Its ecotechnologies complement and supplement nature's own methods.

SESI's services are design, consulting, engineering, product development and sales, and field contracting/construction/vegetation establishment. SESI uses an integrated approach of biosystem optimization, maximizing desired vegetation growth conditions while at the same time controlling rate-limiting factors. The Company is involved in various aspects of ecological engineering, including:

- **BIOENGINEERING**
 - Ecological Restoration
 - Stream & River Corridor Restoration
 - Bioengineered Erosion Control
- **ECOLOGICAL LANDSCAPING**
 - Park and Recreational Facility Construction
 - High Performance Sports Facilities Design & Construction
 - Large Scale Landscaping with Native Plant Materials
 - Restoration Wetlands, Wetland Mitigation
- **NATURAL SYSTEMS FOR POLLUTION CONTROL**
 - Terrestrial Wastewater Treatment Systems
 - Constructed, & Engineered Treatment Wetlands
 - Other Aquatic Wastewater Treatment Systems
- **INTEGRATED ECOSYSTEM MANAGEMENT**
 - Renaturalization/Habitant Creation
 - Watershed Management
- **INDUSTRIAL SOIL ECOLOGY**
 - Soil Blending and Amending
 - Soil Modification
 - Waste Materials Recycling and Reuse
- **BIOREMEDIATION**
 - Soil Bioremediation
 - Phytoremediation
 - Natural and Enhanced Natural Attenuation

Bioengineering, as SESI practices it, is defined as the use of vegetative materials in combination with substrates (organic and/or inorganic) for reconstructing, remediating, stabilizing and/or establishing new morphological and vegetative features. It involves consulting and design-build projects in areas such as restoring, remediating, and revegetating construction and other degraded sites; restoring stream, river and lake shores and corridors; and carrying out bioengineered erosion control activities.

The Ecological Landscaping part of the Company's business involves design-build activities for facilities such as parks, recreational facilities (e.g., golf courses), and sports fields (football, soccer, baseball) and other turfgrass systems, as well as building restoration wetlands for habitat creation and mitigation. The use of biodiverse mixtures of native plant materials indigenous to the areas of projects is important with these.

SESI has particular expertise in the use of Natural Systems for Pollution Control. The Company design, engineers and constructs all sorts of constructed wetlands, including those used for stormwater handling and those used for pollution control (treatment wetlands). It has a particular focus on sub-surface flow (SSF) wetlands, those involving active monitoring and control (engineered wetlands), and those handling difficult-to-treat wastewaters such as leachates. SESI also provides other aquatic wastewater treatment systems (lagoons, floating aquatic plant systems, greenhouse treatment systems), and terrestrial wastewater treatment systems (landfarms, overland flow systems, spray irrigation systems). Consulting, design & engineering activities, field construction jobs, and design-build projects are carried out in this area.

The Integrated Ecosystem Management part of SESI's business involves the enhancement and/or creation of wildlife habitat, renaturalization activities, natural resources and biodiversity monitoring and assessments, natural resource damage assessments, and watershed management activities. Consulting, design, and field implementation projects are carried out.

The Industrial Soil Ecology part of the Company's business involves areas such as the development, manufacture, and establishment of soil-based products (soil blending, manufacturing engineered growth substrates, using and selling geotextiles), and various aspects of soil modification. Both wholesale product sales activities and field construction projects are involved. The Bioremediation part of SESI's business involves areas such as the carrying out of soil bioremediation, landfarming, and phytoremediation projects. Consulting, engineering, and field projects are involved.

SESI is very much a technology development firm as well. It has developed a family of highly innovative, value-added products which are produced from engineered growth substrates (made from proprietary formulations of waste materials, pollution control byproducts, and soil amendments) mixed with specially promoted and pre-germinated vegetative mixtures. PROPASYS™ (from PROPagation SYStem) is a custom-designed rapid vegetation establishment system. The various formulations of PROPASYS™ can be designed with one plant species (e.g., a grass) dominating a particular area but still participating in a healthy, biodiverse ecosystem. Alternatively, wide mixtures of plant species can be propagated in a single application. In addition to PROPASYS™, the Company has developed proprietary ecotechnologies for using waste materials and pollution control byproducts as artificial soils (the ENGINEERED SOIL ecotechnology/family of products); for the sub-surface aeration of terrestrial soil systems and wetland substrates (the SDS ecotechnology); and for advanced erosion control matrix products (the LIVING WEB ecotechnology).

SESI is developing several highly innovative wetlands ecotechnologies. BioReactor Engineered Wetland for wastewater treatment (BREW) is a new concept which integrates SESI's SSF wetlands with its bioreactor capabilities and various of its other ecotechnologies. The Biological Biosolids Control (BBC) ecotechnology integrates SSF wetlands technology with SDS to provide a new method for the dewatering, stabilization and degradation of biosolids such as sewage sludges.

The various parts of SESI's business are inter-related and many activities involve several. (I.e., a constructed wetland project may involve ecological landscaping around the site, including the placement of wet meadow and wetland PROPASYS™ blends.) Soil Enrichment Systems has developed its capabilities to a level at which it can engineer an ecosystem to almost any customer requirement. It can design a stress resistant park of turfgrass, a high performance sports field, dry or wet meadows, a woodland, a low environmental impact golf course, or a marsh.



SESI

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Restoration Technologies for Ecosystems Under Stress

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PHYTOREMEDIATION

Bioremediation is a method used to clean up contaminated soil or water by enhancing the development of large populations of micro-organisms in a manner which brings these organisms into intimate contact with the contaminants. With phytoremediation, plants also play a major role in the clean up. Phytoremediation may be defined as an on site, in situ remediation technique which involves the use of vegetation to remediate or stabilize soils, sludges, sediments, wastewaters or groundwater contaminated with organic or inorganic pollutants. It can be carried out for either terrestrial or aquatic systems and, for the latter, can even involve out hydroponics. There are four basic processes which can occur during phytoremediation:

- PHYTOEXTRACTION
- RHIZOFILTRATION
- PHYTOSTABILIZATION
- PHYTODEGRADATION

Phytoextraction is the utilization of special varieties of plants to extract, transport and concentrate organic and inorganic contaminants from soil or water into harvestable parts of the plants' root systems and above ground biomass (leaves, stems, fruit). Phytoextraction, especially that for heavy metals contaminants, is the technique most commonly associated with phytoremediation.

Rhizofiltration is the use of plant root systems to absorb, adsorb, concentrate and precipitate contaminants from a wastewater stream. Rhizofiltration plays a major role in pollutant clean up in constructed wetlands and other aquatic wastewater treatment systems.

Phytostabilization is the use of vegetation and its associated micro-organisms to alter soil chemistry in a manner which stabilizes and sequesters contaminants and reduces their bioavailability, preventing their entry into food chains.

Phytodegradation is the enhancement of in situ biodegradation through the supply of carbonaceous substrates and oxygen transfer.

With each of the above techniques, the remediation of contaminated soil or water by the plants at their root systems also involves microbial transformations occurring with the aerobic and anaerobic rhizospheric micro-environments which are usually associated with such root systems.

Plants used in phytoremediation effect the clean up both directly by contaminant uptake and subsequent immobilization, volatilization, metabolism and/or other degradation of the contaminants; or indirectly by modifying the abiotic environmental conditions in ways which enhance microbial bioremediation.

A wide variety of vegetation can be used in phytoremediation including herbaceous and woody species, flowers, aquatic macrophytes and even food crops. Some types of vegetation have the ability to "hyperaccumulate" (concentrate 100-fold or more) certain contaminants of interest (trace elements, heavy metals, radionuclides).

SESI defines soil and wastewater contaminants phytoextracted into the plant tissue under three categories:

- NUTRIENTS TAKEN UP AND USED
- HEAVY METALS CONCENTRATED
- ORGANIC CONTAMINANTS TAKEN UP AND METABOLIZED

Both nutrients taken up and heavy metals concentrated in the vegetation can be removed by harvesting.

The advantages of phytoremediation are:

- It is a low cost, in situ, solar-powered and passive ecotechnology.
- It has wide applicability as to the types of contaminants which can be cleaned up using it.
- It involves minimum site disruption and leaves the site in a usable condition.
- It has wide public acceptance.
- It produces no or few byproducts requiring disposal.
- Where plant harvesting is involved, the harvested material can be readily disposed of.

In order for phytoremediation to be possible, the contaminants which one wishes to remediate must be located within the root zone of the plants being used, and then must be bioavailable (i.e., able to be processed and/or adsorbed/transformed by the plants and their associated micro-organisms in some way).

SESI recommends that phytoremediation projects be carried out in up to four stages:

- LABORATORY SCOPING STUDY (Treatability Test)
- GREENHOUSE TEST
- FIELD EVALUATION TESTS
- FULL SCALE PROJECT IMPLEMENTATION

Laboratory scoping studies are very economically carried out in a growth chamber at SESI's facilities using small amounts of contaminated soil or water. Their purpose is to quickly assess the applicability of phytoremediation for a proposed decontamination. With them, the concentrations of the pollutants of interest are measured both before and after certain indicator plants are force grown over 4 - 6 weeks under controlled conditions in the contaminated soil or water (hydroponically in the latter case). The amount taken up, and/or the pollutants metabolized, will be determined by a mass balance. Literature searches may also be carried out as part of scoping studies.

Should scoping study indicate that phytoremediation shows promise, it may be followed by a slightly larger scale set of tests at SESI's facilities with somewhat larger (but still modest) volumes of contaminated soil or water. These tests are carried out in a greenhouse at SESI's site (or, in fair weather and for soil, in associated small outdoor plots), or at a client's site if appropriate conditions are available.

Once lab and greenhouse tests have indicated the applicability of phytoremediation and the best type of vegetation to use, they may be followed by larger scale field tests at the client's site or even by full scale implementation using the systems determined.

SESI will be pleased to provide quotations for phytoremediation services.



SOIL ENRICHMENT SYSTEMS INC.

Restoration Technologies for Ecosystems under Stress

BIOWEB AND LIVING WEB

SIGNIFICANT ADVANCES FOR EROSION CONTROL

In most erosion control projects, especially those involving steep slopes and aquatic-terrestrial interfaces (e.g., shorelines), it is essential to establish a vigorous vegetation cover quickly. Most conventional horticultural and landscaping techniques to do so are expensive, labor intensive and of limited effectiveness, making them unsuitable for many sites. And often the native plant species which are most appropriate for the ecosystem being restored are excluded from the vegetation used.

Conventional seeding and mechanical approaches such as applying sod or hydroseeding (blowing on seed/fertilizer/paper mulches) can be used in some cases but these are generally limited to grass species and a very few others. They also take some time to get established and require favorable growth conditions in order to achieve healthy responses. Under poor climatic and soil conditions, conventional seeding techniques cannot provide a seed bed with optimal growing conditions for the germination of seeds and the early growth of sufficient roots to stabilize the soil and prevent further erosion. Also with conventional seeding, only a small fraction of the seeds survive to germinate and seed mixtures usually cannot include many woody species which are best grown from vegetative cuttings.

Soil Enrichment Systems Inc. (SESI) is an ecological engineering company with a particular focus on the creation, restoration and/or remediation of terrestrial, aquatic and wetland micro-environments. SESI has achieved a significant biotechnological advance with a system called **PROPASYSTM** (from PROPAGation SYStem).

PROPASYSTM is a new method of (re-) establishing vegetation by manipulating physical, chemical and biological properties to suit specific applications and optimize growth conditions. It enhances the normal plant regenerative process by providing a rich humus-like layer for establishing early plant growth. This highly innovative, proprietary ecotechnology and family of products is made by blending propagules (bioengineered mixtures of various plant species including mixtures of seeds, roots, shoots and other vegetative cuttings), engineered growth substrates (made from a variety of materials including waste materials, pollution control byproducts, and soil amendments), and other additives. This combination provides an improved method of getting plants to grow and establish viable and vigorous root systems more quickly and vigorously in a variety of environments.

Rapid vegetation rooting is required in erosion control projects if rainfall and other environmental conditions are not to wash away applied vegetation before it can become established. **PROPASYSTM** is well suited to the task. With **PROPASYSTM**, the target is 15 mm of shoot growth with 80% of the herbaceous species in 5-7 days, something far beyond what is possible with any seeding method.

SESI has carried its PROPASYS™ ecotechnology much further with a number of highly unique products including:

- BIO-WEB
- LIVING WEB
- BIO-LOG
- LIVING LOG

SESI is a distributor of the geosynthetic and erosion control products of BELTON INDUSTRIES, which it uses in its projects and sells to third parties. It has combined the use of Belton's jute and coir (coconut fibre) erosion control webbing and blankets with the application of PROPASYS™ formulations to steep slopes in a proprietary ecotechnology called BIO-WEB. With it, PROPASYS™ is applied to a steep slope (e.g., by blow spreading) and erosion control blankets are placed over it to protect it until it is established. Eventually, the blanket material degrades into a soil builder, leaving the established vegetation. Soil Enrichment Systems has carried out a number of highly successful bioengineered erosion control projects using PROPASYS™ with its BIO-WEB ecotechnology.

SESI has carried the BIO-WEB concept to its logical conclusion with a very highly innovative ecotechnology known as LIVING WEB. With it, at a controlled site remote from its eventual point of application (e.g., a parking lot at SESI's facilities), a suitable PROPASYS™ formulation is placed on a support mechanism (usually special jute erosion control blankets over a plastic sheet), irrigated and caused to begin to grow. Roots from the propagules grow down into and through the support web creating a large, biodiverse "rug" (2-4 metres wide and 10-30 metres long) which can then be rolled up and transported to where it is to be emplaced. The result: instant revegetation.

LIVING WEB is used to provide bioengineered solutions for more demanding applications where an already growing biosystem has been established under very difficult conditions at a location which cannot economically or practically be revegetated otherwise. SESI's LIVING WEB systems have been successfully used in a variety of terrestrial projects to provide sustainable solutions to difficult erosion control and ecological restoration problems. Very steep slope revegetation is a specialty and ones of up to (and including) 90 degrees have been revegetated. It also finds particular application in immediately revegetating large scale underwater areas in wetlands and in dealing with terrestrial-water transition zones subject to wind and wave erosion.

With LIVING WEB, erosion control projects can be completed quickly and economically using biodiverse mixtures of vegetation native to an area. LIVING WEB blankets are held in place until full root establishment with temporary stakes which are later removed, although permanent LIVING STAKES which develop into bushes can also be provided.

SESI has also combined its PROPASYS™ ecotechnology with a variety of other jute and coir-based products such as erosion control "logs" (3 to 10 metre long, 15 to 30 centimetre diameter sausages of jute and/or coir) to provide economic and unique solutions to a variety of renaturalization, rehabilitation and restoration applications. With BIO-LOG, vegetation (often PROPASYS™-based) is established in the log at the site where it is being used for shoreline protection, stream bank restoration or a number of similar applications. With LIVING LOG, vegetation is pre-established in the log before it is transported to the site where it will be used in a manner analogous to that of LIVING WEB. BIO-LOG and LIVING LOG are just a few PROPASYS™-based product lines provided by the Company, either for installation by SESI or for sale to qualified landscapers.

SESI erosion control products not just substrates with seeds and growing shoots in them; they are complex, living biosystems ready to be established at customer sites. No other company offers anything like PROPASYS™ and the erosion control products such as LIVING WEB which can be made using it. Ecological niches with different soil, microclimate and moisture regimes can be vegetated using them. They are orders of magnitude more sophisticated than other replanting and erosion control techniques.



SESI

SOIL ENRICHMENT SYSTEMS INC.

Restoration Technologies for Ecosystems under Stress

PROPASYSTM

Soil Enrichment Systems Inc. (SESI) is an ecological engineering company with a particular focus on the creation, restoration and/or remediation of terrestrial, aquatic and wetland micro-environments. SESI has achieved a significant advance in developing a biological/environmental technology (ecotechnology) called **PROPASYSTM** (from **PROP**agation **SY**stem). **PROPASYSTM** is a *custom-designed rapid vegetation establishment system for use in specific applications*. It is used to provide biodiverse plant cover of whatever sort customers want, and is proven and fully commercialized; having been used on dozens of successful bioengineering, wetland, landscaping, restoration, site remediation, phytoremediation, and erosion control projects.

There are now a number of varieties of **PROPASYSTM** and each variety may have several formulations, so **PROPASYSTM** can be described as a family of products. The ecotechnology involves a variety of interrelated sub-systems as well (e.g., production, blending, application, establishment), so **PROPASYSTM** is also an integrated systems technology.

PROPASYSTM is made by blending propagules (pre-germinated vegetative mixtures) with engineered growth substrates (humus-like artificial soil materials) and other additives to create highly innovative, vegetative communities. This combination provides an improved method of getting plants to grow and establish viable and vigorous root systems more quickly and vigorously in a variety of environments.

Propagules are bioengineered mixtures of various plant species including seeds, shoots and other vegetative cuttings, and contain all that is needed to establish vegetation as part of an integrated healthy biosystem. Most of the seeds and cuttings in propagules are pre-treated to minimize the time required to generate vigorous and dense vegetation on a site. This pre-treatment involves dormancy breaking and the pre-germination of seeds and/or the inducement of root and shoot growth on vegetative cuttings. SESI has developed proprietary methods to ensure that a wide variety of vegetation can be propagated. In order to include woody species (shrubs, trees) in a propagule mix, some **PROPASYSTM** formulations also contain rooted and non-rooted stem and root cuttings.

The engineered growth substrates of **PROPASYSTM** are made by blending a variety of waste and other materials including:

- WASTE MATERIALS
- POLLUTION CONTROL BYPRODUCTS
- SOIL AMENDMENTS AND CONDITIONERS
- OTHER ADDITIVES (e.g., sand, loam)
- COMPOST

PROPASYSTM's growth substrates are engineered to have all the physical, chemical and biological properties of good, humus-rich soils, and additionally to be much more resistant than are ordinary soils to environmental stresses such as compaction. (SESI's engineered growth substrates are also sold separately - i.e., without propagules - as the ecotechnology/family of products called **ENGINEERED SOIL**).

APPENDIX 16

Bird Strike Committee USA - meetings, information

8th MEETING: BIRD STRIKE COMMITTEE USA

June 16-18, 1998 * Burke Lakefront Airport * Cleveland, OH

Theme: *Practical Wildlife Control Techniques for Airports*

Located in downtown Cleveland, Burke Lakefront Airport is in walking distance of Rock & Roll Hall of Fame, Jacob's Field, Gund Arena, Great Lakes Science Center, Lake Erie, The Flats Entertainment District, Tower City and Galleria shopping centers, rapid transit, gull nesting colonies, and more!

Every year, billions of dollars are wasted and lives are endangered worldwide when birds and other wildlife damage aircraft. To meet this ongoing challenge, the FAA, USAF, USDA and Aviation Industry Wildlife Hazards Working Group present the 8th annual meeting of Bird Strike Committee USA, June 16-18, 1998 at Burke Lakefront Airport (BKL) in Cleveland, Ohio. BKL provides an ideal location to address wildlife/airport issues because of its proximity to Lake Erie, wetlands, gull nesting colonies and other abundant bird life. Holiday Inn is only 0.8 mile from BKL.

WHO SHOULD ATTEND

This annual gathering is of particular interest to military and civilian personnel responsible for airfield operations, wildlife managers, land-use planners, FAA airport inspectors, university researchers, engineers, pilots, aviation industry representatives--anyone interested in reducing bird strike hazards to aircraft! For further information, contact a Steering Committee member listed below.

PROGRAM

Presentations include papers, posters and demonstrations on wildlife control techniques, new technologies, land-use issues (landfills, wetlands), training, engineering standards, and habitat management. The meeting will emphasize hands-on demonstrations and activities (e.g., grass height plots, bird capture/scare techniques, bird biology, telemetry) during a field trip to BKL, a nearby gull colony and surrounding areas. A strike reduction training session rounds out the program.

EXHIBITS

The program will include exhibits featuring the latest in bird and mammal damage control devices. Companies interested in participating should contact Gene LeBoeuf at the address below.

TENTATIVE PROGRAM OUTLINE

Monday, June 15 (1800-2000)
Evening Social and Registration

Tuesday, June 16 (0800-1700)
Registration, Guest Speakers, Technical Sessions, Panel Discussion, Cleveland Indians Baseball

Wednesday, June 17 (0800-1700)
Hands-on field demonstrations and activities on Burke Lakefront Airport and at nearby gull colony, Exhibitor social, Canada/USA Water Volleyball

Thursday, June 18 (0800-1700)
Technical Sessions, Military and FAA Training Sessions, Close-out Session with Committee

REGISTRATION (see form on reverse side)

Pre-registration payment deadline is May 1 = \$60
On-site registration = \$75
Make Check or Money Order payable to:
USDA/Wildlife Services
Sorry, no Credit Cards or Purchase Orders

HOTEL RESERVATIONS

Please call Holiday Inn Lakeside (216-241-5100).
Room rates are \$89/night. Mention BSC-USA.

BSC-USA STEERING COMMITTEE MEMBERS:

Richard Dolbeer, (Chair), USDA/APHIS, 6100 Columbus Ave., Sandusky, OH 44870 (419-625-0242)
Laura Henze, USDA/APHIS, 463 West St., Amherst, MA 01002 (413-253-2403)
Eugene LeBoeuf, USAF BASH, 9700 Ave G, SE, Bldg. 24499, Kirtland AFB, NM 87117 (505-846-5679)
Pete Windler, USAF BASH, 9700 Ave G, SE, Bldg. 24499, Kirtland AFB, NM 87117 (505-846-5674)
Edward Cleary, FAA, AAS 317, 800 Independence Ave., SE, Washington, DC 20591 (202-267-3389)
Tom Hupf, (Vice Chair), FAA Tech Center, ACM 433, Atlantic City Intl Airport, NJ 08405 (609-485-5841)
Paul Eschenfelder, Air Line Pilots Assoc., 16326 Cranwood, Spring, TX 77379 (281-370-3925)
Ron Merritt, (Sec/Treas), Geo-Marine, 8317 Front Beach Rd, Panama City Beach, FL 32407 (850-230-5919)

SEE REVERSE SIDE FOR REGISTRATION FORM



8th BIRD STRIKE COMMITTEE USA MEETING
June 16-18, 1998

Holiday Inn Lakeside/Burke Lakefront Airport
Cleveland, Ohio

CONFERENCE AND FIELD TRIP REGISTRATION FORM

Please print or type—complete a separate form for each participant

Name _____

Title _____

Organization _____

Address _____

City _____ State _____ Zip _____ Country _____

Phone _____ Fax _____ Email _____

REGISTRATION FEES:

_____ Conference Pre-Registration (by May 1, 1998) - \$60
(includes coffee breaks, socials, field trip with buffet on Nautica Queen, program)

_____ Conference Registration (after May 1 and on-site) - \$75
(includes coffee breaks, socials, field trip with buffet on Nautica Queen, program)

_____ Additional Nautica Queen Ticket - \$25

Total Amount Enclosed _____

METHOD OF PAYMENT:

_____ Check or money order enclosed. Make payable to: USDA/WS

RETURN TO:

Betsy Marshall, USDA/APHIS/WS
6100 Columbus Avenue
Sandusky, OH 44870
(419) 625-0242; fax (419) 625-8465
nwr@sandusky@lrbcg.com

For Office Use Only

Amt: _____ Ch#: _____ Date: _____

DID YOU KNOW THAT?

- Over 300 people have been killed world-wide as a result of bird strikes.
- Wildlife strikes cost U.S. aviation over \$250 million/year, 1993-1995.
- Over 2,500 bird strikes are reported by the U.S. Air Force/year.
- About 2,300 bird strikes/year were reported for U.S. civil aircraft, 1992-1996.
- An estimated 80% of bird strikes to U.S. civil aircraft go unreported.
- Gulls (31%), blackbirds (13%) and waterfowl (12%) were the most commonly reported birds struck by U.S. civil aircraft, 1992-1996.
- Over 310 civil aircraft collisions with deer were reported in the U.S., 1983-1997.
- A 12-lb Canada goose struck by an 150-mph aircraft at lift-off generates the force of a 1,000-lb weight dropped from a height of 10 feet.
- Starlings are "feathered bullets", having a body density 27% higher than herring gulls.
- Over 500 million blackbirds and starlings migrate to the southern U.S. each winter.
- The North American non-migratory Canada goose population tripled, 1985-1995.
- The Great Lakes cormorant population increased from only about 200 nesting adults in 1970 to 160,000 nesting adults in 1995, an 800-fold increase.

- The North American white pelican population grew at an average annual rate of 3.1%, 1980-1996.
- At least 30 nesting colonies of gulls were located on roofs in U.S. cities on the Great Lakes, 1994.
- Over 99% of all bird strikes in the U.S. are by species federally protected under the Migratory Bird Treaty Act.

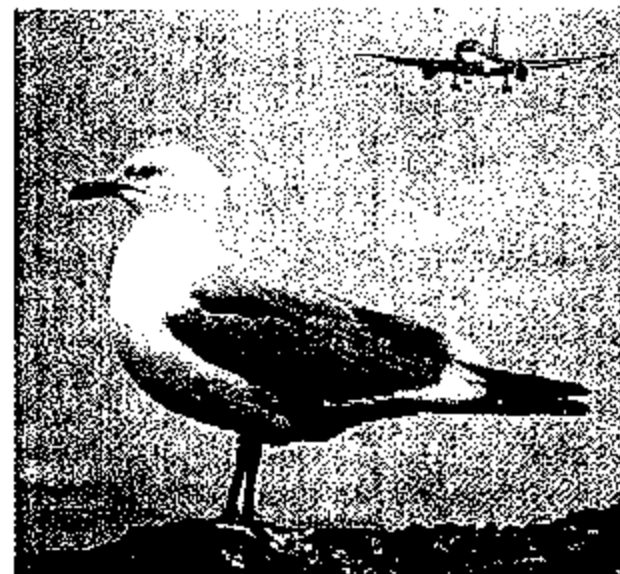
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SAFER SKIES FOR ALL WHO FLY



BIRD STRIKE COMMITTEE USA

An Overview



For further information contact:

Richard Dolbeer, Chair, BSC-USA
6100 Columbus Avenue
Sandusky, OH 44870
(419) 625-0242
(419)-625-8465 fax
nwresandusky@lrbcg.com

WHY HAVE A BIRD STRIKE COMMITTEE USA?

Bird and other wildlife strikes to aircraft annually cause over \$250 million in damage to U.S. civil and military aviation. Furthermore, these strikes put the lives of aircraft crew members and their passengers at risk: over 300 people have been killed as a result of bird strikes. Within the United States there was no one forum where information or concerns dealing with this problem could be addressed. Bird Strike Committee USA was formed in 1991 to facilitate the exchange of information, promote the collection and analysis of accurate wildlife strike data, promote the development of new technologies for reducing wildlife hazards, promote professionalism in wildlife management programs on airports through training and advocacy of high standards of conduct for airport biologists and bird patrol personnel, and be a liaison to similar organizations in other countries.

Bird Strike Committee USA is directed by an 8-person steering committee consisting of 2 members each from the Federal Aviation Administration, US Department of Agriculture, Department of Defense, and the aviation industry Wildlife Hazards Working Group.

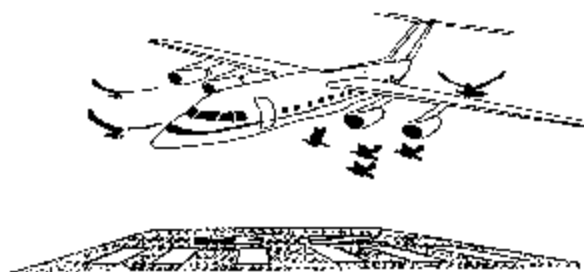
WHEN AND WHERE DOES BIRD STRIKE COMMITTEE USA MEET?

The organization meets annually, typically in association with an airport.



WHAT HAPPENS AT A BIRD STRIKE COMMITTEE USA MEETING?

There typically are four parts to a Bird Strike Committee USA meeting over 3 days. Part 1 consists of the presentation of papers or reports. Part 2 is a vendor and poster session. Part 3 is a training session on wildlife control at airports which covers both civil and military aviation. Part 4 is a field trip which generally covers the host airport and areas off the airport which pertain to aviation or aviation safety.



WHAT SUBJECT AREAS ARE COVERED DURING THE PAPERS AND REPORTS PORTION OF THE MEETING?

- bird and other wildlife strike reporting/statistics
- bird management and control techniques
- research on new technologies to reduce wildlife hazards
- training in wildlife management on airports
- military concerns of wildlife hazards
- aircraft, engines and components related to wildlife hazards
- policy concerning wildlife hazards
- land use and environmental issues concerning airports
- bird migration and general ornithology
- workshops and round-table discussions

ARE THERE ANY BIRD STRIKE COMMITTEE USA PUBLICATIONS?

Attendees of the annual meetings receive abstracts of the technical papers presented and a list of all attendees and addresses. Copies of papers presented may be obtained from authors who choose to provide them.

WHO ATTENDS BIRD STRIKE COMMITTEE USA MEETINGS?

Participation in the annual meetings is open to any person interested in reducing wildlife hazards to aviation and in wildlife management at airports. As examples, meeting announcements are currently mailed to the following groups:

- Aircraft Owners and Pilot Association
- Aircraft and Aircraft Engine Manufacturers
- Air Line Pilots Association
- Airports Council International, NA
- American Association of Airport Executives
- Airport Managers
- Air Transport Association
- Bird Strike Committee Canada
- Engineering/Environmental Consulting Firms
- FAA Regional Airport Certification Personnel
- International Bird Strike Committee
- International Civil Aviation Organization (ICAO)
- State Wildlife Agencies
- University and Private Research Facilities
- USDA Wildlife Services State Directors
- US Fish and Wildlife Service Regional Directors
- US Military Aviation Groups

APPENDIX 17

Bosik Consultants Ltd.

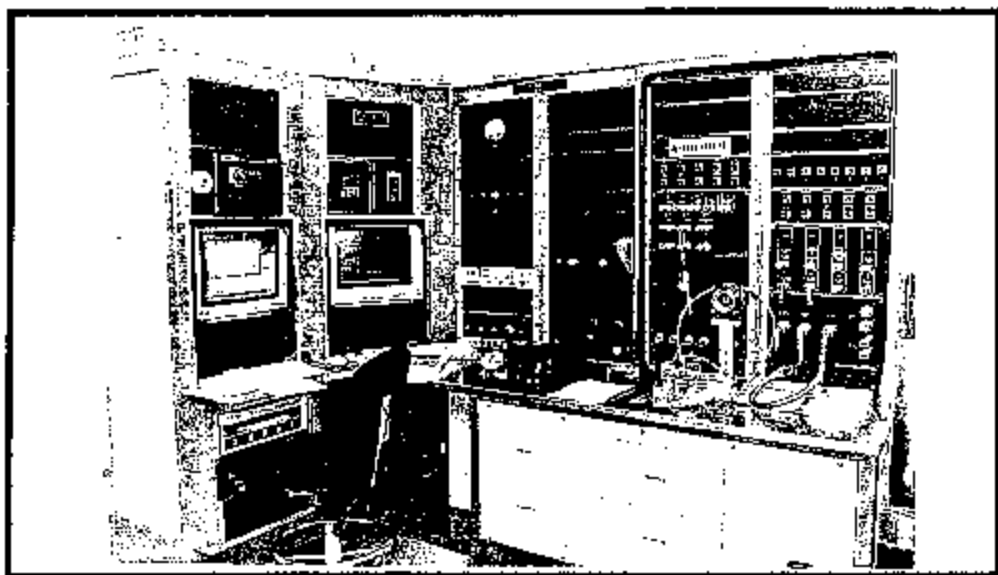
BCL

Bosik Consultants Limited

Background

A registered corporation in the Province of Ontario, *Bosik Consultants Limited (BCL)* was founded in July, 1989 in order to pursue engineering activities and to offer contract research and development services. BCL employs fundamental aeronautical/mechanical engineering principals toward a wide range of applications.

Services include: development of specialized equipment from conceptual design through to construction and commissioning; studies pertaining to transportation including aerospace and ground vehicles; specialized testing including bird impact, shock, ballistics, bomb blast and flight recorder impact; related studies and investigations.



Above: Fuel Controls Test Stand, front view

Systems Integration

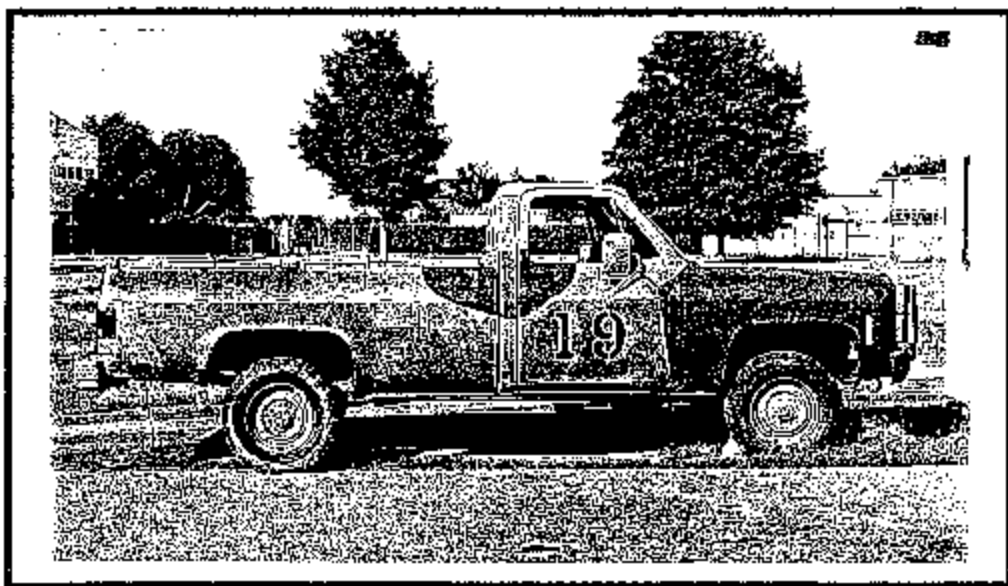
Projects integrate fundamental mechanical engineering principles in the disciplines of solid mechanics, thermodynamics, fluid mechanics and dynamics as well as finite analysis to the design and development of specialized equipment including:

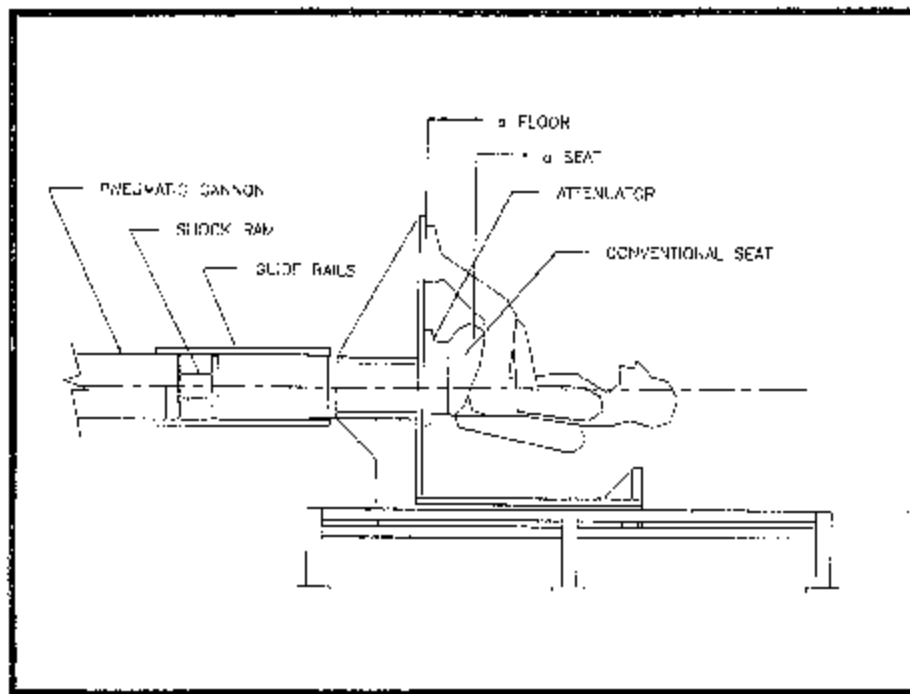
- fuel test stands
- force measurement systems (dynamic or static)
- process equipment
- specialized drives and mechanisms

Security and Protection

- military and high security vehicle blast attenuation and ballistic protection
- bomb blast and fragment containment systems
- blast and ballistic testing

Right: Military vehicle equipped with blast protection





Aerospace Design with AUTOCAD and Mechanical Analysis

- mechanical/aerospace design, drafting and analysis
- available to compliment designs or as a stand alone service
- stress, vibration, shock, fluids and thermal investigation
- Design/Test to ASME Boiler Code or Military shock and vibration specifications

Left: Seat shock attenuation testing

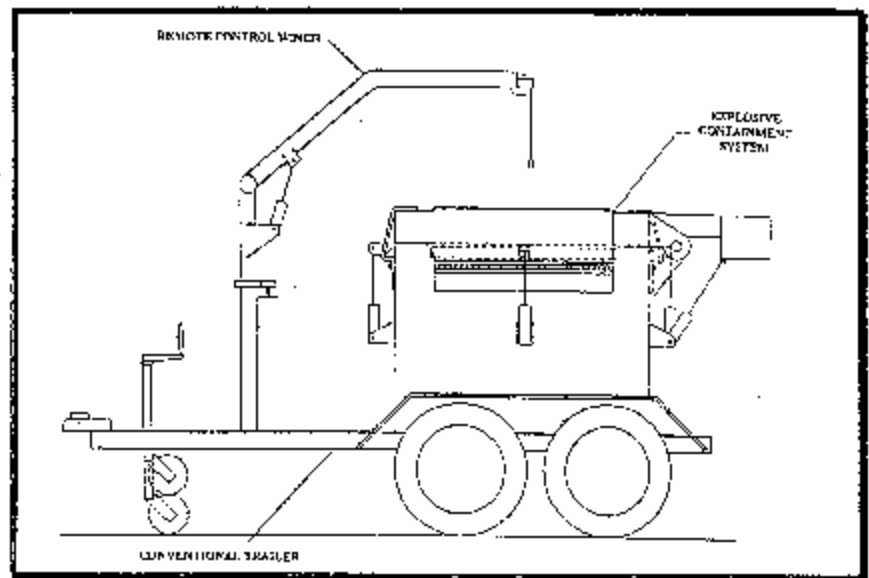
Vehicle Engineering (Ground and Aerospace)

- design and fabrication of both aerospace and ground vehicle test equipment

Ground vehicle engineering includes:

- prototype design of novel vehicular concepts, compliance testing of production vehicles, as well as fuel consumption and exhaust emissions testing and evaluations (evaluated to demonstrate compliance with CMVSS)
- design and fabrication of specialized equipment for the mobility challenged

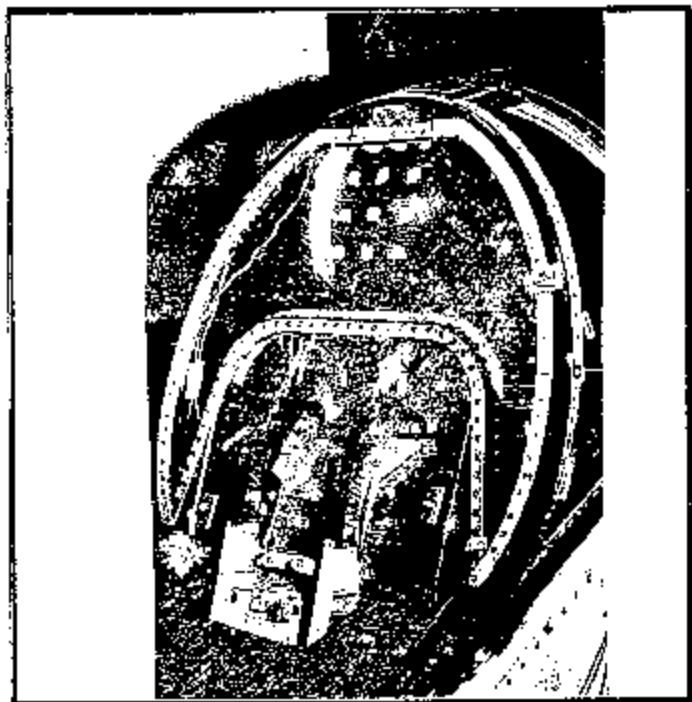
Right: Bomb disposal unit



Related Services:

- vehicle and industrial accident reconstruction through analysis, simulation and testing
- expert witnesses available for litigation purposes if required for investigation

Left: Vehicle Crash



Above: Aircraft windshield post bird impact

Impact Testing

BCL offers a capability in impact testing which is unique to Canada. BCL operates the National Research Council of Canada's (NRCC) Flight Simulator Facility located at the NRCC Uplands Airport Campus in Ottawa, Ontario, Canada.

The facility includes a large pneumatic gun (10 inch barrel diameter) and a smaller gun (3.5 inch barrel diameter) used to test a variety of items

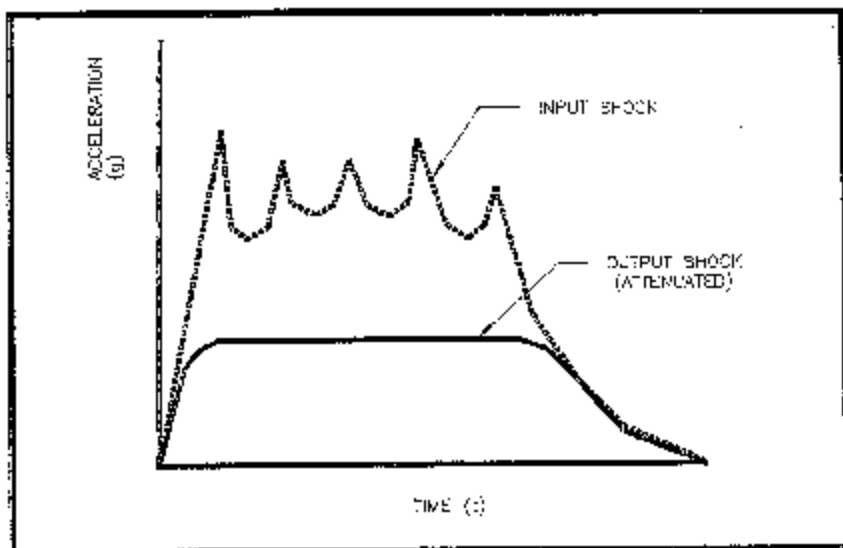
Testing capabilities include:

- **Bird Impact** : birds are propelled to their target in order to simulate bird strikes with aircraft components, typically windshield and wing/empennage leading edges
- **High G Shock testing**: for seats and other applications
- **Bomb Blast**: arranged for specific applications
- **Flight Recorder 3400G impact**: tested to meet EUROCAE ED-55 AND ED-56A
- **Ballistic Testing**: please see back cover for details

Aerospace and Mechanical Prototyping and Fabrication

- fabrication of highly specialized equipment
- proficiency in fabrication processes (welding, machining, painting, etc.) and materials
- in-house fabrication facilities
- strong rapport with external fabricators, educational institutions and government agencies

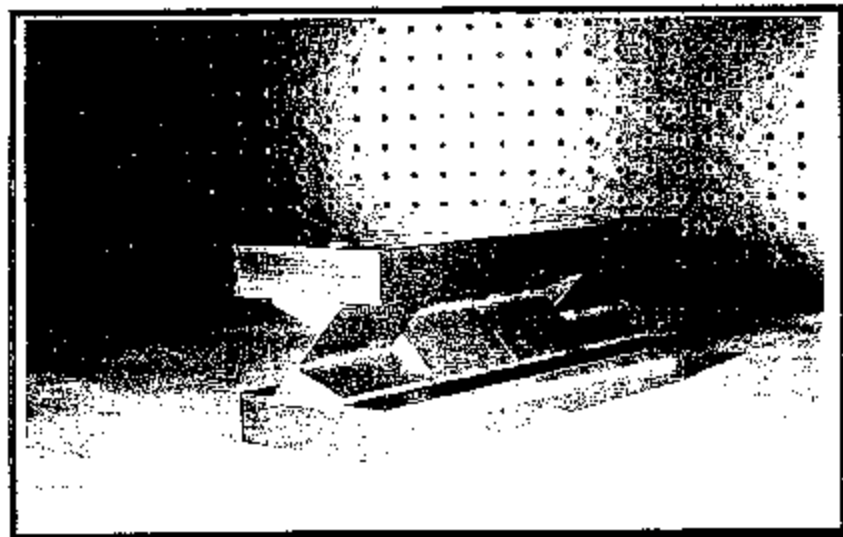
Right: Impact test results

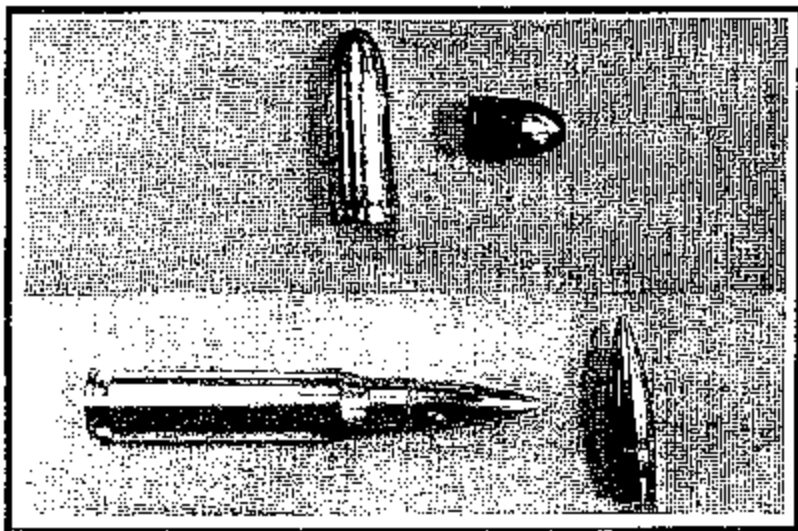


Energy Evaluation

- energy study construction including analysis of a variety of energy saving devices
- engine/vehicle fuel consumption evaluation and testing of complete vehicles or components
- monitoring of various thermal systems
- design and evaluation of solar energy systems, active and passive

Right: Flexure, used in dynamic weighing systems





Above: ammunition employed in ballistic testing
Upper row: 9mm FMJ ammunition;
Lower row: 7.62 NATO BALL ammunition

Ballistics Lab

The National Research Council of Canada (NRCC) Ballistics Facility constitutes part of the Flight Impact Simulator (A Government of Canada National Facility). BCL employs the facility to various ends including:

- Ammunition Evaluation
- Weapons Evaluation
- Design and Q/A testing of body armour
- Contaminants measurement of ammunition
- Special Fixturing
- Preparation of test materials
- See separate insert for further details

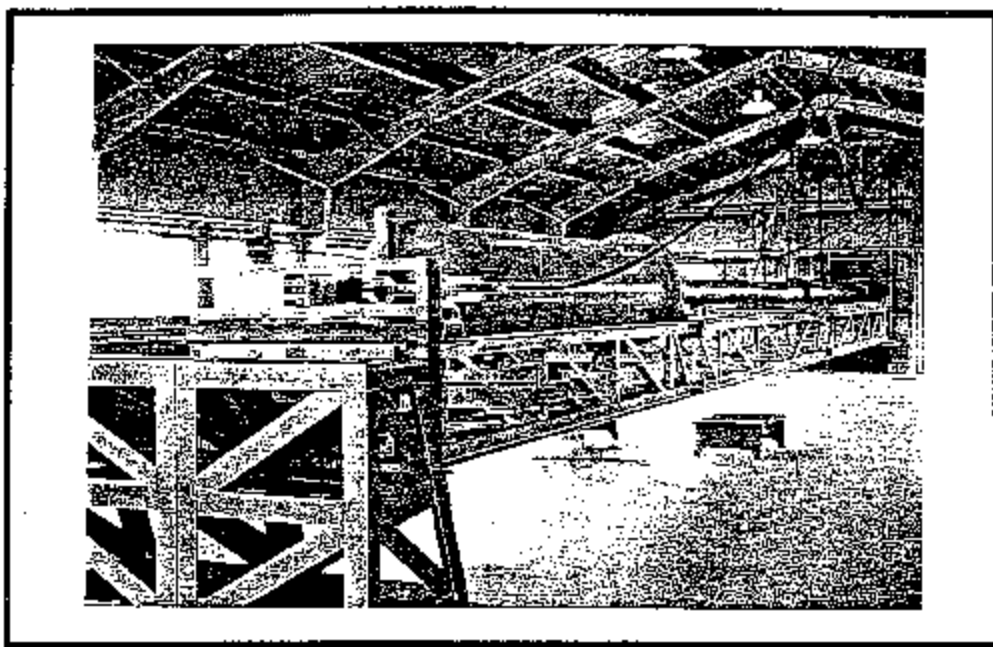
Facilities

BCL's operates the NRC facilities consisting of a complete office and laboratory area of approximately 6500 sq.ft. The laboratory includes:

- large air canon
- impact testing zone
- ballistics test range
- machine shop and prototyping area
- secured 24 hrs/day

Staff

The key staff at BCL have considerable experience in various areas of mechanical engineering. The staff draws on their experience to obtain additional expertise, facilities, and support staff in order to meet the requirements of their clients. BCL readily teams with other organizations (public, private or university) in order to meet project needs.



Above: Large air canon employed in impact testing

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 5460 Old Mill Way
 Manotick, Ontario, Canada
 K4M 1C1

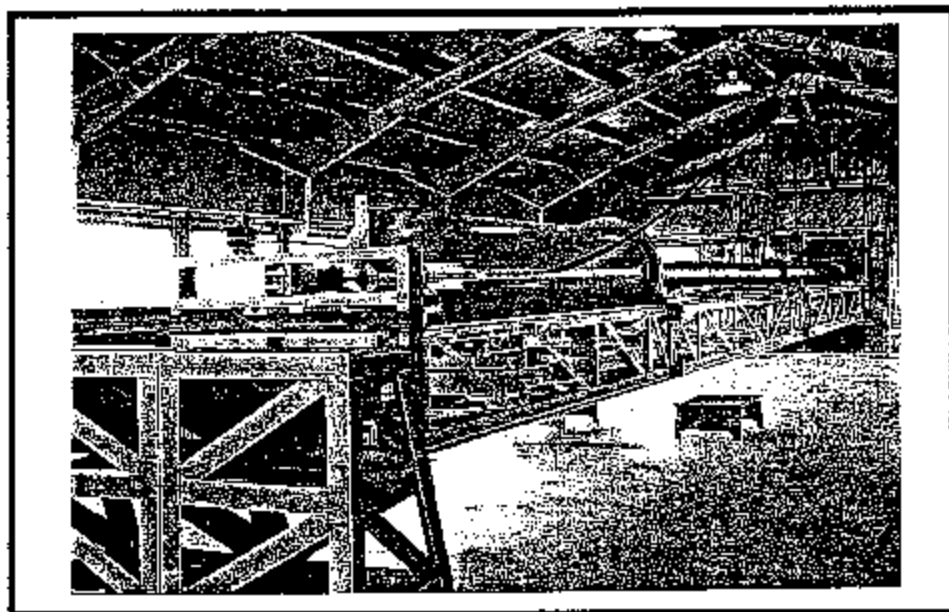
Laboratory Address
 Building U-69
 National Research Council of
 Canada, Uplands Airport Campus
 Ottawa, Ontario, Canada
 K1A 0R6

Office Phone: (613) 998-3303
Lab. Phone: (613) 998-3303
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E-mail: toddhosik@cyberus.ca

BCL

Bosik Consultants Limited

HIGH G IMPACT TESTING



Large air cannon employed in impact testing

Operating the National Research Council of Canada's (NRCC) Flight Impact Simulator Facility in Ottawa, Ontario, Bosik Consultants Limited offers a unique capability in impact testing. BCL performs High G shock testing for a variety of test items to meet both client specifications and industry standards.

Services

- 3400 G impact testing of flight recorders to EUROCAE ED-55, 56A
- Aircraft and automotive seat impact testing to 500 Gs
- Seatbelt impact testing
- Miscellaneous testing to 30,000 Gs

Facility

The NRC Flight Impact Simulator facility includes a large pneumatic gun (10 inch barrel diameter) and a machining area equipped for fixturing test-specific items. The large pneumatic gun, measuring approximately 75 feet in length, is employed to propel test items to their impact points.

The facility is furnished with the technology and equipment necessary to attain reliable test data, including:

- Velocity timing frame
- Load cells
- High speed cameras
- Movias motion analyzer
- Energy absorbing systems
- Strain gage equipment
- Non-contact deflection measurement
- Digital scope(s)

For further information regarding BCL's High G Impact testing capabilities, please contact:

Mailing address:
5460 Old Mill Way
Manotick, Ontario, Canada
K4M 1C1

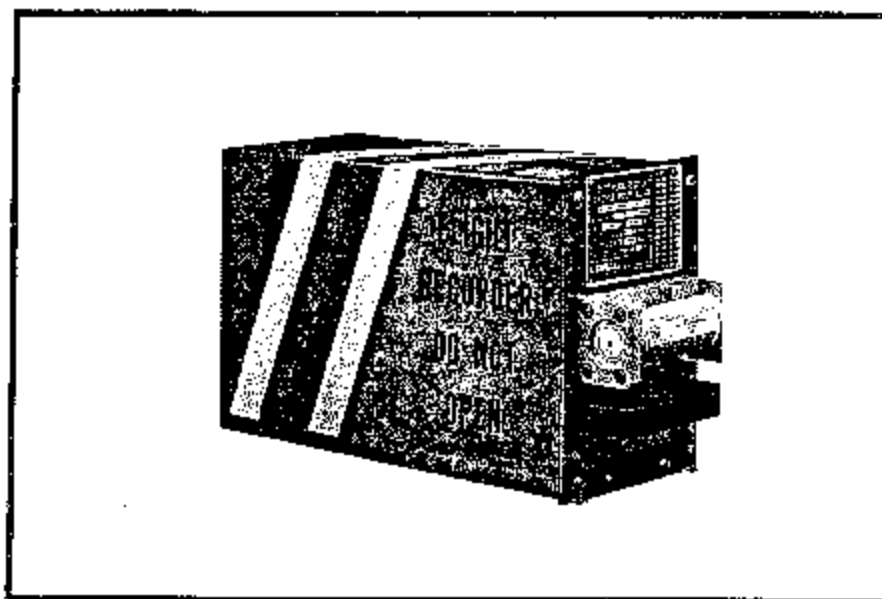
Laboratory Address:
Building G-69
National Research Council of
Canada, Uplands Airport Campus
Ottawa, Ontario, Canada
K1A 0R6

Office Phone: (613) 998-3303
Lab. Phone: (613) 998-3303
Fax: (613) 998-3084
E-mail: toddbosik@cyberus.ca

BCL

Bosik Consultants Limited

FLIGHT RECORDER STUDIES AND EVALUATION



Flight Data Recorder

Bosik Consultants Limited offers engineering capabilities directly applicable to the 3400 G impact testing of Flight Data Recorders (FDR) and Cockpit Voice Recorders (CVR) according to the EUROCAE ED-55, 56A standards.

Services

- Impact testing (3400 G EUROCAE ED-55, 56A)
- Design and fabrication of fixturing
- Environmental and structural evaluation
- Mechanical design, fabrication and testing
- Studies on survivability, aircraft location

Instrumentation

- Large pneumatic gun (10 inch barrel diameter), employed to propel objects to their impact points
- Support and tie-down structures
- Velocity timing devices
- Environmental conditioning
- High speed photography
- Accelerometers
- Non-contact velocity measurement
- Load cells

Additional Testing

- Deep sea pressure
- Penetration resistance
- Static crush
- Fluid immersion

Analysis

Bosik Consultants Limited may also assess various properties of FDRs and CVRs in accordance with specific industry needs. To this end, past projects have included a study on the optimal location of these devices toward greater survivability, an analysis of the merits of dual combined CVR/FDR Flight Recorder Installations and an evaluation of the survivability of ULRs.

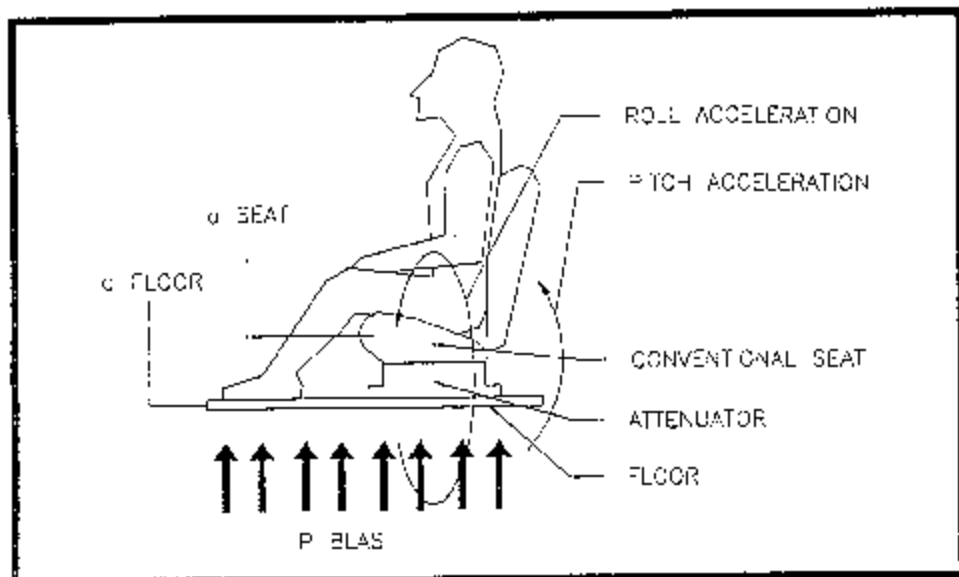
Mailing address:
5460 Old Mill Way
Manotick, Ontario, Canada
K4M 1C1

Laboratory Address:
Building U-69
National Research Council of
Canada, Uplands Airport Campus
Ottawa, Ontario, Canada
K1A 0R6

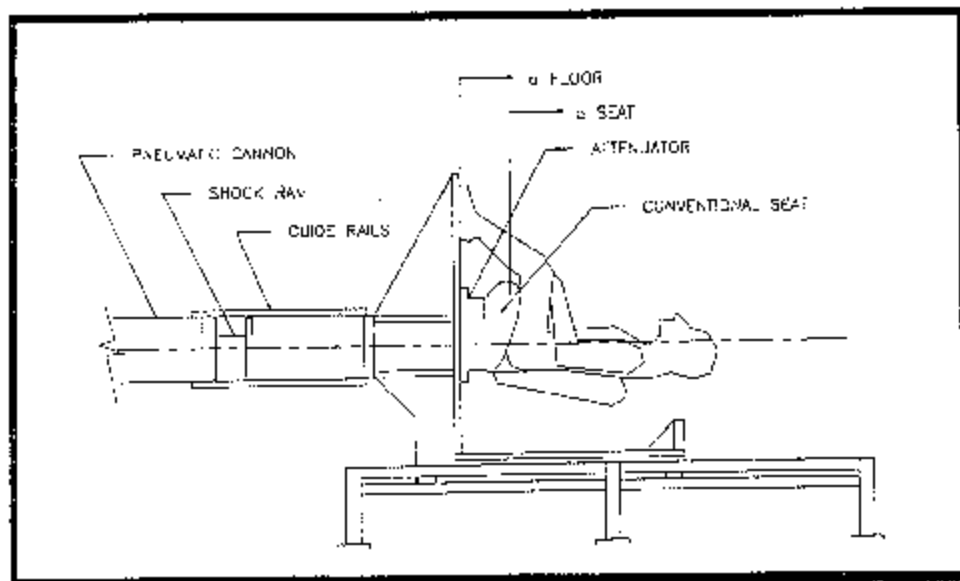
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E-mail: toddbosik@cyberus.ca

BCL**Bosik Consultants Limited**

SEAT SHOCK REDUCTION



Seat Attenuation System



Seat Test System

Background

An exploding land mine beneath a truck exerts significant forces on the truck and its occupants. Even large trucks (such as a 15 ton military vehicle) subjected to a 7 Kgr. mine face accelerations on the vehicle floor of up to 100 and 200 Gs. It is therefore necessary to reduce the acceleration levels to approximately less than 20 Gs in order to ensure the survival of the vehicle's occupants.

Attenuation System

BCL's approach to controlling the maximum G levels generated by explosion includes attenuating elements in the vertical and lateral directions to account for the various forces exhibited during a blast. The attenuation is used with a standard seat and reduces the acceleration to safe levels.

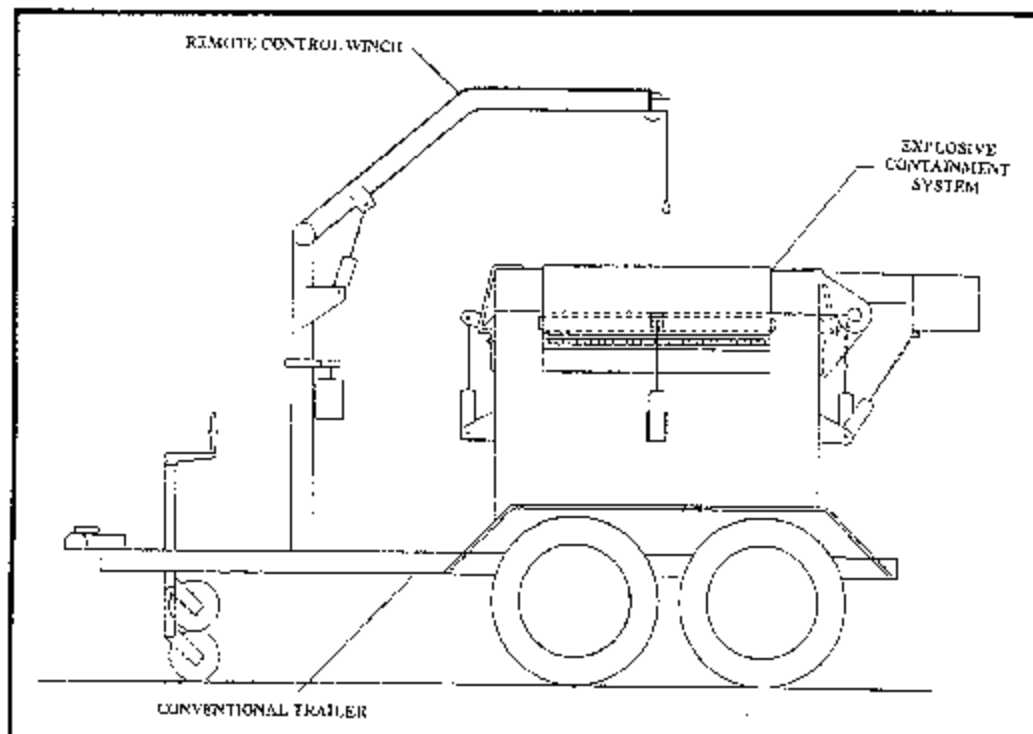
Testing

A large (10 inch barrel) pneumatic gun is employed to provide the energy to conduct seat tests that simulate the critical conditions encountered during a mine blast. This test method can be used to evaluate the performance of standard seats or those modified to survive the G loading from mine blasts. The "floor" G levels can be varied from one to approximately 500 Gs.

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Monrovia, Ontario, Canada
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Lab Phone: (613) 998-3302
Fax: (613) 998-3084
E-mail: toddbosik@cyberus.ca

BOMB CONTAINMENT AND DISPOSAL*Explosion containment system, conceptual design*

With the objective of offering a superior explosion containment and disposal alternative, Bosik Consultants Limited developed a light-weight containment/disposal system now available for direct purchase. Each system is custom designed for the specific requirements of the client. The new BCL system offers:

- potentially 1/3 the weight of current containment systems
- complete containment of gases (option)
- custom designed to withstand more than 20 lbs of explosives
- utilization of air, hydraulic or electrical actuators for the opening and locking of doors
- completely enclosed or open system, according to specifications

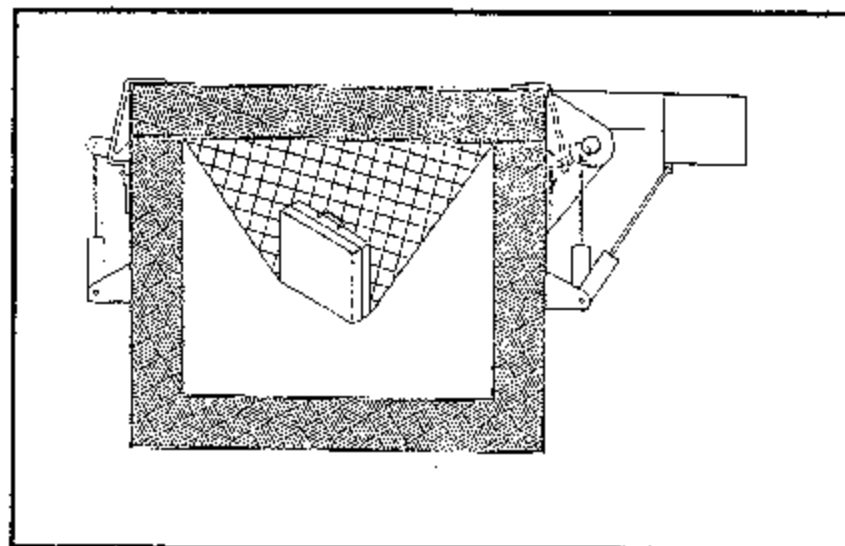
Each unit can be stationary or mobile, trailer-mounted. These devices also feature a vertical reaction member in order to reduce the effects of the blast on the suspension system of the trailer. Available options include:

- manual or remote hoist for loading and unloading (model dependent)
- tandem axle trailer
- electric brakes
- battery and charger
- storage bins

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Laboratory Address:
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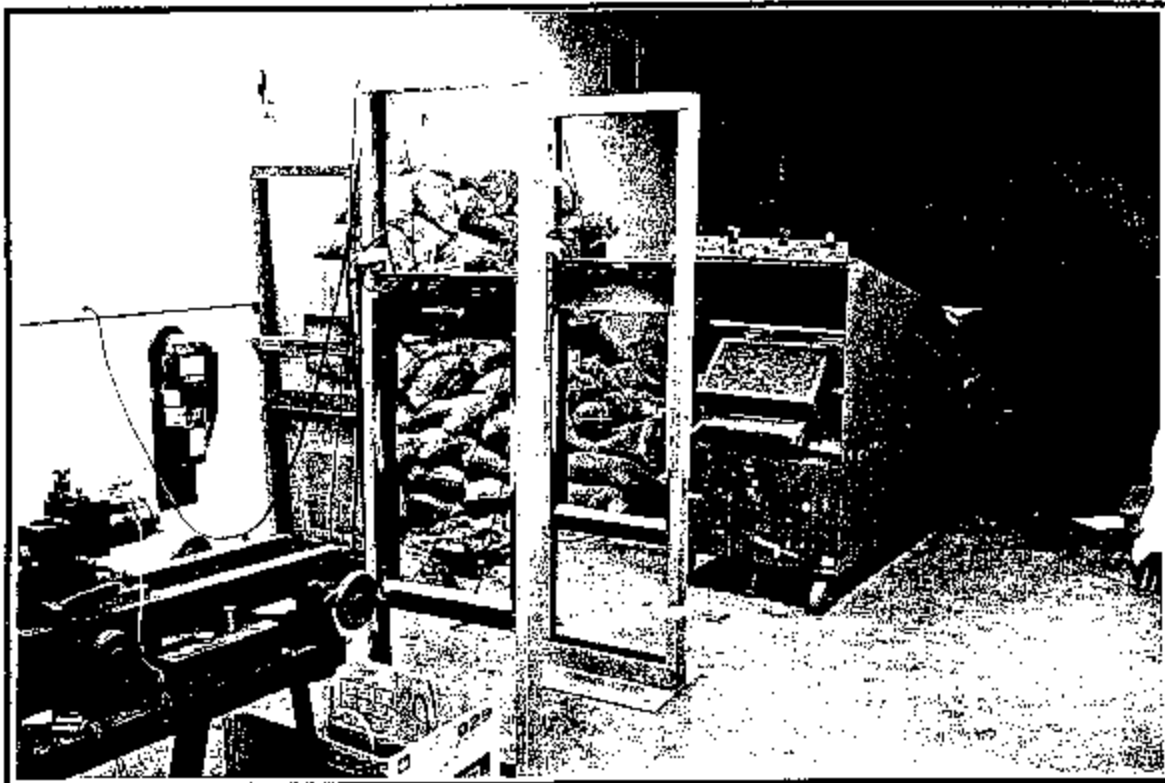
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Fax: (613) 998-3084
E-mail: todd@bosik.cyberus.ca

*As above, sectional view*

BCL

Basik Consultants Limited

BALLISTICS TEST FACILITY



Ballistic test range, up to approximately 30 meters (100 feet)

BCL operates the National Research Council of Canada (NRCC) Ballistics Facility, located as part of the Flight Impact Simulator Facility in Ottawa, Ontario, Canada (A Government of Canada National Facility). This facility is currently being certified to the Canadian Standard (CGSB), U.S. N.I.J., and U.S. O. 9000.

Ballistic Services

Ammunition Evaluation

(to .38 cal.)

- Pressure tests
- Velocity measurement (VS/VR)
- Accuracy evaluation
- FBI Protocol testing
- Penetration measurements in ballistics gelatin
- Clothing penetration
- Miscellaneous material testing
- Ammunition loading
- Bullet weight retention

Weapons Evaluation

- Hand guns all calibers
- Rifles to 7.62 mm
- Ballistic fragment simulators

Design and Testing of Protective Equipment and Materials

- Body armour
- Helmets
- Glass

- Bullet proof enclosures
- Bullet proof materials
- Turbine blades
- Vehicle armory
- Materials QA testing

Other Services

- Contaminants Measurement
- Spall Determination
- Special Fixturing
- Preparation of test materials
- Energy Measurement

Facility

BCL's ballistic facility is secured and safe storage is available for weapons and ammunition. The facility is suitable for hand gun and rifle testing up to approximately 0.38 caliber.

The facility includes:

- Body armour test mannequin (Goldorac 2)
- Computerized Data Acquisition and Reporting
- Velocity Measurement systems
- Barrel conformal pressure transducers
- Bullet trap
- Ballistics Pendulum
- Still and high speed cameras
- Scales
- Universal receiver and gun barrels
- Equipment for manufacturing ballistics gelatin, test materials and fixtures
- Numerous fixtures for holding test samples
- Chamber for measuring pollutants (lead etc.)
- Statistical database and analysis
- Hand loading equipment

Test Materials

- Ballistics Gelatin
- FBI Protocol test materials including: light clothing, heavy clothing, steel sheets, wallboard, plywood, automobile glass
- Walls: cement, steel-reinforced, brick
- Fuel containers: gasoline and propane
- Typical Commercial aircraft cabin interior, skin and cabin window
- Road surfaces: paved, crushed stone
- Automobile components: skin, windshields, doors

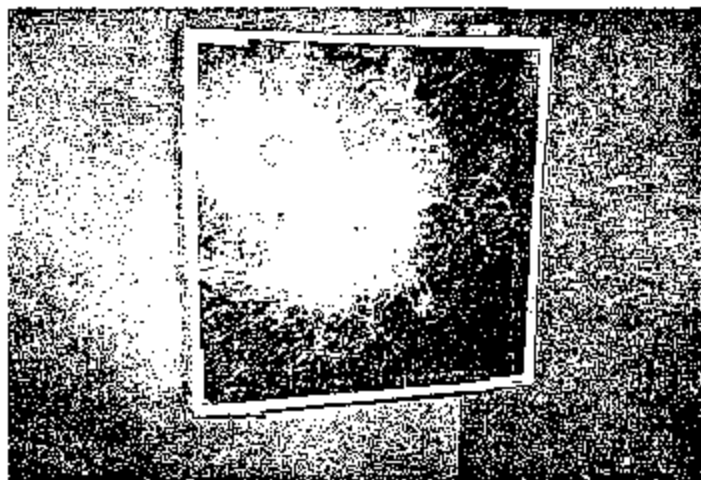
Contact

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Office Phone: (613) 998-3303
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E-mail: todd.bosik@cybernet.ca

Mailing address:

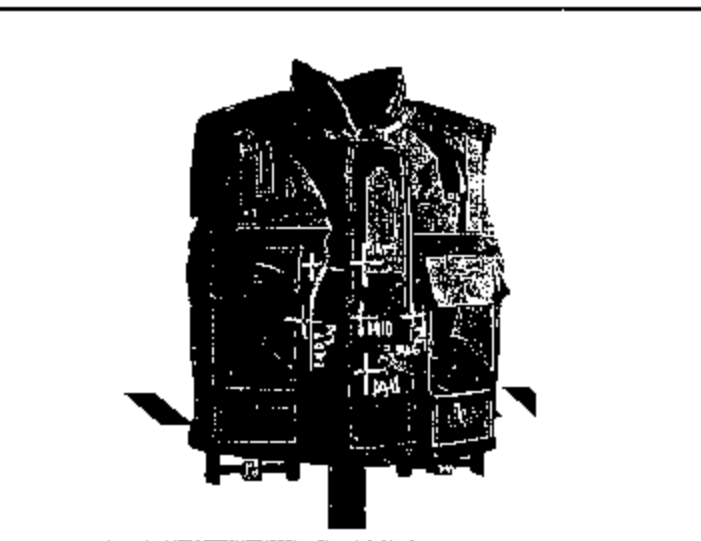
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Manotick, Ontario, Canada
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Glass panel post ballistic impact



Helmet post ballistic impact



Goldorac 2, an adjustable torso mechanism employed in body armour testing

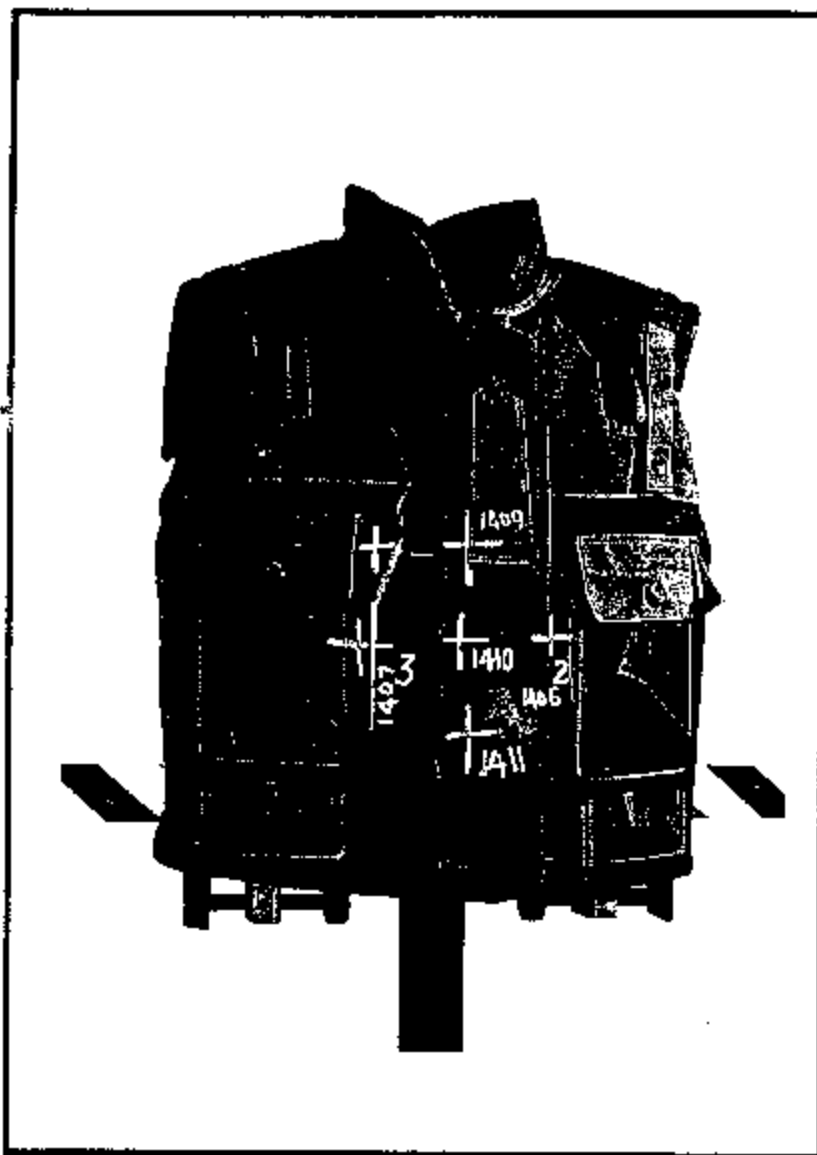
BCL

Bosik Consultants Limited

GOLDORAC 2 TM

Body Armour Test Rig

Bosik Consultants Limited is pleased to announce the commercial launch of a new advancement in body armour testing now available for direct purchase. The Defense Research Establishment Valcartier (DREV) of the Canadian National Defence has developed the uniquely effective **Goldorac 2**, an adjustable torso designed to hold a curved tray block to best recreate the natural curvature of the human body. The **Goldorac 2** has become part of the Canadian standard for ballistic testing (CGSB Standard ACG-6481-C-179/1, Personal Body Armour) and is currently being recommended for the European standard.



Goldorac 2 with body armour

Product Description and Design Features

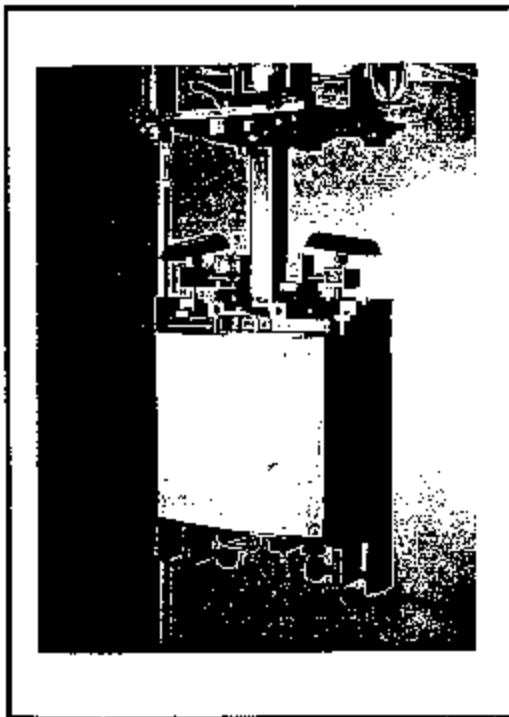
The Goldorac 2 represents a significant advance in ballistics research with features uniquely valuable to body armour testing.

Defining characteristics of the Goldorac 2 were developed in direct response to specific industry needs. Features include:

- **curved tray** closely simulates the human form while ensuring the maintenance of close contact between the body armour and the underlying body simulant (plasticine)

- **fully adjustable torso**, (width, height and depth adjustable); suitable for testing body armour of various sizes

- **rear tray**, fabricated from a hard armour removable steel plate; extends the benefits of the Goldorac 2 to include the testing of ceramic breast plates; removable rear plate allows clay to be calibrated for consistency



Ceiling support model

Testing

The Goldorac 2 has undergone over one year of testing and has benefited from added improvements. The curved tray block was enlarged to allow for the ballistic testing of ceramic breast plates while the design of various components was simplified toward greater cost-effectiveness. The Goldorac 2 successfully withstood ballistic testing with handgun and rifle on body armours of various sizes.

The Goldorac 2 represents a unique union of research and development expertise; through its successful correction of deficiencies of the past, it has become the model of proficiency for ballistic body armour testing of the future.

Availability

Bosik Consultants Limited maintains an exclusive agreement with the Canadian National Defence to produce and market the Goldorac 2.

To order the Goldorac 2, please contact:

Anthony Bosik, M. Eng., P. Eng., President
Bosik Consultants Limited

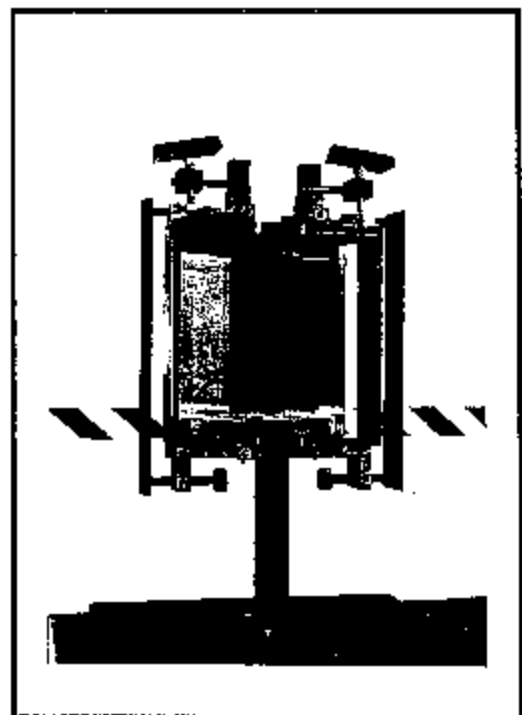
5460 Old Mill Way ▶ Manotick, Ontario, Canada ▶ K4M 1C1 ▶ Office: (613) 998-3303

Lab: (613) 998-3303 Fax: (613) 998-3084 ▶ E-mail: toddbosik@cyberus.ca

Advantages

The unique features of the Goldorac 2 endow this new mechanism with distinct advantages over its predecessors:

- ▶ new, adjustable torso allows for easy adaptation to any size of body armour
- ▶ includes both floor and ceiling support models adaptable to any test environment; successfully retains specific positioning orientation (normal and angle) required by ballistic standards
- ▶ includes curved clay block to ensure the close fit between body armour and body simulant essential to obtaining reliable and repeatable performance data
- ▶ designed specifically for effective ballistic testing; durable and highly robust



Floor support model

APPENDIX 18

Capabilities of the NRCC/NAE Flight Impact Simulator Facility

UNLIMITED
UNCLASSIFIED

**CAPABILITIES OF THE NRCC/NAE FLIGHT IMPACT
SIMULATOR FACILITY**

CAPACITÉ DU SIMULATEUR D'IMPACT EN VOL DU CNRC/ÉAN

by/par

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National Aeronautical Establishment

**OTTAWA
MAY 1983**

**AERONAUTICAL NOTE
NAE-AN-13
NRC NO. 21379**

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SUMMARY

This report describes the NRCC/NAE Flight Impact Facility in which birdstrike tests on aircraft parts can be carried out. Technical information is given on the capabilities of the pneumatic cannon used to fire real bird carcasses against stationary targets, and on the auxiliary apparatus and instrumentation available at the Facility.

SOMMAIRE

Ce rapport décrit le Simulateur d'impact en vol du CNRC/ÉAN destiné aux essais d'impacts d'oiseaux contre les composantes d'avions. On présente des renseignements techniques sur le canon pneumatique qui sert à lancer des carcasses d'oiseaux contre des cibles fixes, ainsi que des renseignements sur les appareils auxiliaires et les instruments de mesure disponibles sur place.

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CAPABILITIES OF THE NRCC/NAE FLIGHT IMPACT SIMULATOR FACILITY

1.0 INTRODUCTION

Research and development in the field of bird impact resistance of aircraft has been and remains a significant activity within the National Aeronautical Establishment (NAE), a division of the National Research Council Canada (NRCC). In 1968 at the request of Canadian Industry the NAE set up a Flight Impact Simulator Facility in which bird strikes on aircraft components can be simulated and the resulting structural damage can be studied under laboratory conditions. The principal tool of the Facility is a pneumatic cannon which can propel bird carcasses against stationary targets at speeds up to 390 m/sec.

Since publication of the report "Capabilities of the NAE/NRC Flight Impact Simulator Facility" in 1974, many improvements have been implemented. Upper and lower velocity limits have been extended, environmental conditioning equipment and procedures have been improved, high speed filming techniques have been refined, and instrumentation has been updated.

It is the purpose of this report to provide information on the present capabilities of the Facility.

2.0 THE FACILITY

2.1 The Site

The Facility is located on the NRCC/NAE grounds adjacent to Ottawa International Airport. The Facility is housed in a building consisting of two areas, one that contains the pneumatic cannon and support equipment, and a test area in which the specimens are located. A plan view of the test area is shown in Figure 1. Located approximately 45 meters from the end of the building is a semi-circular embankment with a perimeter fence that secures the area. Along the line-of-fire, set into the embankment, is a 2.4 X 2.4 X 2.4 meter wooden crib to arrest bird packages during calibration shots.

2.2 The Pneumatic Cannon

The cannon is shown in Figure 2 and schematically in Figure 3. It consists of a 1.70 m³ reservoir (working pressure 1380 kilopascals), a 0.03 m³ step chamber, Figure 4, and a 12.2 m long by 25.4 cm bore barrel. At the barrel muzzle is a spring-mounted sabot arrestor (Fig. 5).

The cannon support frame can be pivoted at the reservoir end for aiming. The frame can also be raised or lowered to facilitate testing of various size specimens. The impact point can vary from one to three meters above the target area floor.

The cannon utilizes a double diaphragm system for pressurizing and firing. The reservoir and step-chamber are pressurized simultaneously in the ratio of 2:1, to the predetermined test pressure, each of the two diaphragms supporting one-half of the reservoir pressure. Diaphragms of various burst pressures are selected so that they will support one-half reservoir pressure but will burst at full pressure.

The cannon is fired by energizing two large-port solenoid valves, quickly releasing the step-chamber pressure. Full reservoir pressure now successively ruptures the two diaphragms and the energy of the compressed air accelerates a sabot containing the bird package down the barrel. The sabot is retained by the sabot arrestor and the bird package continues to the impact point.

2.3 Sabot

International air-worthiness codes have established 0.9, 1.8, and 3.6 kg birds as standard weights for impact testing.

Because of the large barrel diameter, various package weights (0.45 to 4.5 kg) can be used at the Facility. A sabot is required to contain the bird packages, but it is also vital for supporting the birds during acceleration.

Sabots of various metal alloys and thickness, with a filler material of aluminum honeycomb or polyurethane foam, have been developed. Different container-filler combinations are used depending on the required bird package size and velocity.

At present the sabot — sabot arrestor system can be used successfully for a 1.8 kg bird at velocities up to 400 m/sec. Figure 6 shows the sabot components, bird package, and sabot with bird package ready for firing. Figure 7 shows examples of spent sabots.

2.4 Birds and Packaging

All bird impact testing at the facility is carried out with domestic chickens. The birds are selected by weight, asphyxiated, packaged in air-tight polyethylene bags and frozen for storage.

Prior to use the birds are thawed at room temperature for at least 24 hours (0.9 and 1.8 kg birds) or 48 hours (3.6 kg birds).

The bird weight and final bird package weight is recorded, just prior to use.

Packaging of the bird varies with the required velocity. Low velocities require only that the polyethylene storage bag be wrapped with a number of turns of masking tape. At extremely high velocities heavy nylon bags are required to prevent the bird from disintegrating during initial acceleration.

For approximately 90% of the impacts carried out at the Facility, the bird in the polyethylene is packaged in a light cotton bag. This packaging is used for velocities up to 215 m/sec.

2.5 Diaphragms

The diaphragms used in the cannon are cut from Mylar (polyester) film in thicknesses ranging from 0.025 to 0.25 mm. The consistent bursting pressure exhibited by this material is an important factor in maintaining the predictability and reliability of the velocity imparted to a bird package.

An in-house study of the bursting characteristics of the Mylar diaphragms indicated that variables such as pressure rise rate, stacking of diaphragms, creep under load, artificial heat aging, and creasing did not significantly affect the burst pressure. It was found, however, that the burst pressure of diaphragms of the same thickness but of different lot or mill run could vary by as much as 35%. Consequently, burst testing is carried out on each new lot of film received.

2.6 Specimen Set-Up and Targeting

Typical test set-ups are shown in Figure 8, while Figure 9 is a drawing of the primary supporting structure available at the Facility.

A helium-neon laser is used for positioning the test specimen so that the proper impact point is obtained. The laser is placed in the muzzle of the cannon such that the laser beam is aligned with the axis of the gun barrel. The specimen is then moved until the impact point coincides with the laser beam. The beam is also used as a reference to set the longitudinal axis of the test article. Sweep-back angles are set to within $\pm 1/2^\circ$ with an apparatus employing the laser beam as a reference. The apparatus is shown being used in Figure 10. Pitch and roll angles are set by means of a clinometer to within $\pm 1/2^\circ$.

2.7 Environmental Conditioning

The temperature of a transparency is an important parameter in bird impact testing. Typical temperature requirements range from a low of -40°C to a high of 50°C and soak times can be as long as one or two hours depending on specimen thickness. The Facility has a number of methods of carrying out temperature conditioning.

If a complete front fuselage section containing the test transparency must be conditioned, a chamber can be set up to enclose the complete fuselage section. The chamber can be erected to a maximum size of 3.7 m by 4.9 m by 3 m high. The erected environmental chamber is shown in Figure 11.

Most of the impact testing, however, can be carried out by heating or cooling only the transparency. For these tests an insulated enclosure, with cover, is fitted around the specimen. Conditioned air is then ducted into the enclosure until temperature requirements are met. A few seconds before firing the cannon the cover is removed remotely so as not to interfere with the impact. Figure 12 shows a typical enclosure with the cover removed.

Both enclosures are suitable for either high or low temperature tests.

For the low temperature testing air mixed with liquid nitrogen in a mixing box, shown in Figure 13, is ducted into the enclosure. Heated air from an oil-fired unit heater is ducted directly to the enclosure for the high temperature work.

Two other methods can be used for the high temperature tests. One utilizes the heat generated from the high intensity lights required for motion picture photography. A second procedure is to apply heat to the test specimen with a flexible heating blanket. The outer face of the blanket is covered with insulation and the temperature is controlled by varying the applied voltage. The insulating cover and blanket are removed prior to impact. The set-up, during heating, is shown in Figure 14.

2.8 Instrumentation

2.8.1 Velocity Measurement

The velocity of the bird package prior to impact is the single most important parameter to be measured in any impact test.

The Facility utilizes a timing frame (Fig. 15) with optoelectronic timing systems that measure the time interval for a bird package to traverse the known distance, (nominally 0.8 m) between a pair of light beams. Redundancy is provided by three independent systems mounted horizontally, diagonally, and vertically (Fig. 16), all perpendicular to the line of fire.

The recorded test velocity is the mean obtained from the three systems.

Calibration of the timing systems is carried out regularly. An apparatus with a tube representing a bird package is positioned centrally along the horizontal axis of the timing systems. The tube is moved slowly through the light beam of a particular system to the point where triggering of a timer-counter will not occur by interruption of the whole light beam. The tube is then moved in the opposite direction until triggering can now occur by beam interruption. This "go no-go" band is approximately 0.13 mm wide and is taken as the trigger point for the particular timing unit. The procedure is repeated for the remainder of the "start" and "stop" units and the interval distances are read from a scale attached to the apparatus to an accuracy of ± 0.25 mm. The apparatus, in position, is shown in Figure 17.

2.8.2 Bird Weight

The weight of the bird and complete bird package is measured just prior to use on an electronic scale with a resolution of ± 1 g. The scale is checked periodically with a set of calibrated weights.

2.8.3 High Speed Film Coverage

The facility has two 16 mm Hycam cameras capable of filming at the rate of 10 000 frames per second. A quarter-frame prism is also available which can produce 40 000 quarter-frame pictures per second. An additional two Fastex 16 mm cameras are also on hand.

A photo-optical data analyzer is used for viewing the high speed films in the Facility's projection room. Normally the negative is available the day following the impact test.

Lighting for filming is supplied by banks of high intensity aircraft landing lights and long-duration high-intensity flash bulbs. The latter are used for confined spaces.

2.8.4 Still Photographs

The Facility is well equipped with cameras for still photography. Both 35 mm and Polaroid cameras are used.

The Facility also has a light table for back lighting of damaged transparencies. As can be seen in Figure 18, use of the table highlights the fracture surfaces of a damaged specimen.

2.8.5 Temperature Measurement

Grid-type copper-constantan thermocouples at various points on a transparency are used to monitor the temperature. In most cases two thermocouples are employed, one on the outside surface at the impact point and one on the inside surface of a transparency. These are monitored simultaneously on digital indicators and strip-chart recorders, so that an instantaneous reading at impact and a temperature-time history can be obtained. At present a total of four thermocouple channels are normally available. However, a data logger for monitoring additional thermocouples can be made available if required.

2.8.6 Strain Measurement

Recently, impact tests have been carried out requiring strain measurements of windwhield panels. The Facility is experienced in the recording, analyzing and processing of such data.

In another recent test, measurements were made of the peak force and force-time history on a leading edge section during an eight-pound bird impact. A steel plate (152.4 cm long by 30.48 cm wide, by 2.54 cm thick) backed by two 22,700 kg load cells, was designed for the tests. A schematic of the test set-up is shown in Figure 19. The data was collected on a digital oscilloscope and magnetic tape recorder, and processed by a graphic system with a hard copy output.

2.8.7 Ballistic Pendulum

The Facility has ballistic pendulums which may be used to measure impulses and momentum transfer during bird impacts. A program to study momentum transfer during bird impacts has been carried out at the Facility and is reported in Reference 1, which also contains a full description of the pendulums. The pendulums are currently being used in an R & D program to develop a bird-resistant composite leading edge for airfoils. A schematic of a typical test set-up is shown in Figure 20. If penetration of the test specimen occurs the ballistic pendulum mounted behind the specimen measures the residual momentum of the bird debris. The ratio of residual momentum to initial bird package momentum is a useful measure of the relative performance of different leading edge designs.

3.0 PERFORMANCE

The majority of testing carried out at the Facility utilizes a 1.8 kg bird package, with velocities ranging from 90 to 300 m/sec.

Figure 21 shows the general pressure versus velocity relation for this range. The graph shown in Figure 21 is a mean curve based on the results of several hundred firings of the gun. The actual velocity attained in any one shot will vary somewhat from the mean curve because of normal and uncontrollable variations in ambient conditions, in sabot weights and other factors. The extent of the variation is shown in Figures 22, 23 and 24 in which are plotted the individual data points on which the curve of Figure 21 is based. The extreme variation from the mean curve is of the order of ± 8 m/sec throughout the complete velocity range. On average, however, the departure from the mean curve is much smaller than this. For example, at a pressure setting of 60 kPa the mean velocity is 76.2 m/sec and the standard deviation of the observed velocities is 2.1 m/sec. At a pressure setting of 250 kPa the mean velocity is 185 m/sec and the standard deviation is 1.5 m/sec.

Velocities below 61 m/sec are achieved by the use of a throttle plate at the reservoir outlet and by inserting the sabot at various distances (normally 3 m) from the muzzle.

The maximum attainable velocity is limited by the allowable working pressure of the reservoir. Under normal operating conditions the maximum velocity of a 1.8 kg bird package is about 330 m/sec. This can be increased to 390 m/sec by the installation of a mylar diaphragm at the muzzle and evacuation of the barrel prior to firing. The maximum velocity can be further increased by using helium, instead of air, as the driving gas. With helium, a 0.9 kg bird package has been successfully fired at a velocity of 465 m/sec using a reservoir pressure of 690 kPa. This pressure is only one-half of the maximum allowable reservoir pressure. Obviously the maximum velocity of a 1.8 kg package could be increased substantially with helium as the driving gas, but containing the sabot at these speeds requires further development work.

The curves of pressure versus mean velocity for 0.9 kg and 3.6 kg bird packages are shown in Figures 25 and 26 respectively. The gun is fully calibrated for the following bird package weights and velocity ranges:

0.45 kg bird from 37 to 213 m/sec
0.90 kg bird from 15 to 213 m/sec
1.80 kg bird from 30 to 387 m/sec
3.60 kg bird from 76 to 229 m/sec

4.0 UTILIZATION OF THE FACILITY

The Facility has been in continuous operation since its inception in 1968. Over 2000 shots have been fired.

Several in-house research projects have been carried out at the Facility. These include a study of single-ply windshields of the type used in light aircraft (Refs. 2, 3), an investigation of the effect of aging on the impact resistance of polycarbonate (Ref. 5), and measurements of momentum transfer in bird impacts on flat plates (Ref. 1). An investigation of the bird impact resistance of various designs of leading edges is near completion.

In addition to in-house research projects, numerous bird impact tests have been carried out for the following external organizations:

Canadair Ltd.
De Havilland Aircraft of Canada Ltd.
Department of National Defence, Canada
PPG Industries Inc.
McDonnell Douglas Aircraft Corp.
Fairchild Republic Co.
Federal Express Ltd.
Sierracin Sylmar Corp.

Certification of aircraft components for compliance with Transport Canada and FAA standards of bird impact resistance has been an important part of the work of the Facility. Looking to the future, one can foresee a continuing need for bird impact investigation as new materials and new light-weight designs are introduced.

5.0 REFERENCES

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Gould, R.W. NRCC/NAE Laboratory Technical Report LTR-ST-1259, April 1981.
2. Heath, J.B.R. *Bird Impact Test Program for Windshields of Small Light Aircraft.*
Bosik, A.J. Conference on Aerospace Transparent Materials and Enclosures, Atlanta, Ga., November 1975, AFML-TR-76-54, pp. 854-885.
3. Bosik, A.J. *A Study of Bird Impacts on Monolithic Aircraft Windshields.*
Heath, J.B.R. NRCC/NAE Laboratory Technical Report LTR-ST-998, April 1978.
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Heath, J.B.R. NRCC/NAE Laboratory Technical Report LTR-ST-1043, December 1978.
5. Heath, J.B.R. *Degradation of the Bird Impact Resistance of Polycarbonate.*
Gould, R.W. NRCC/NAE Laboratory Technical Report LTR-ST-1326, January 1982.

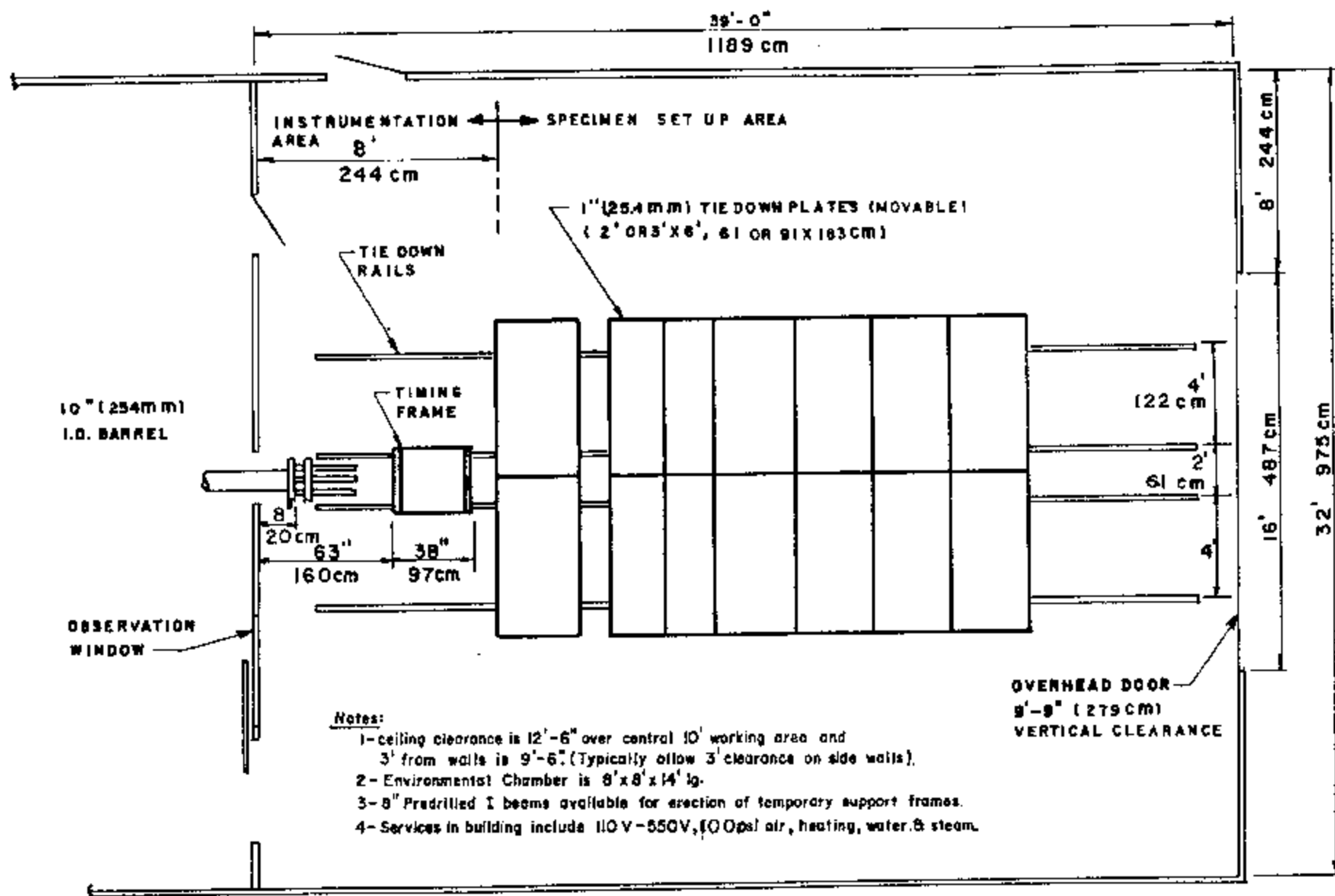


FIG. 1: PLANVIEW OF NAE FLIGHT IMPACT SIMULATOR TEST AREA

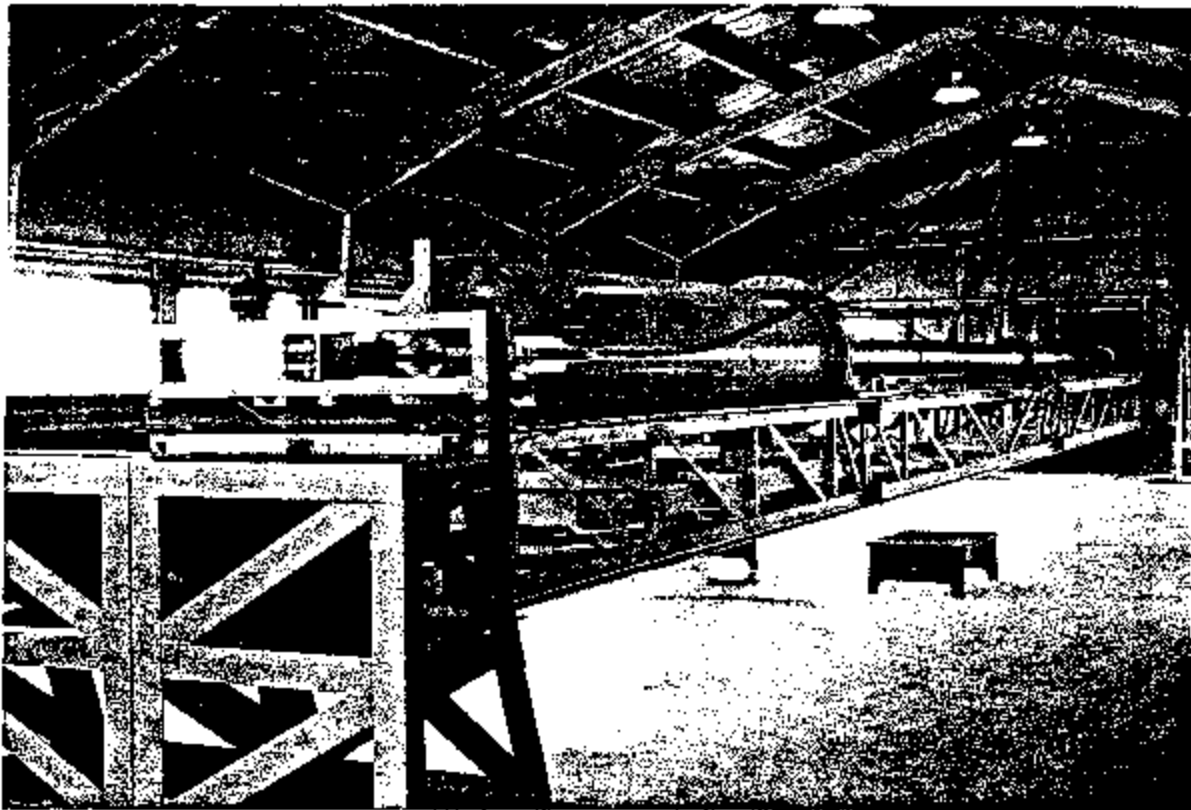


FIG. 2: OVERALL VIEW OF CANNON

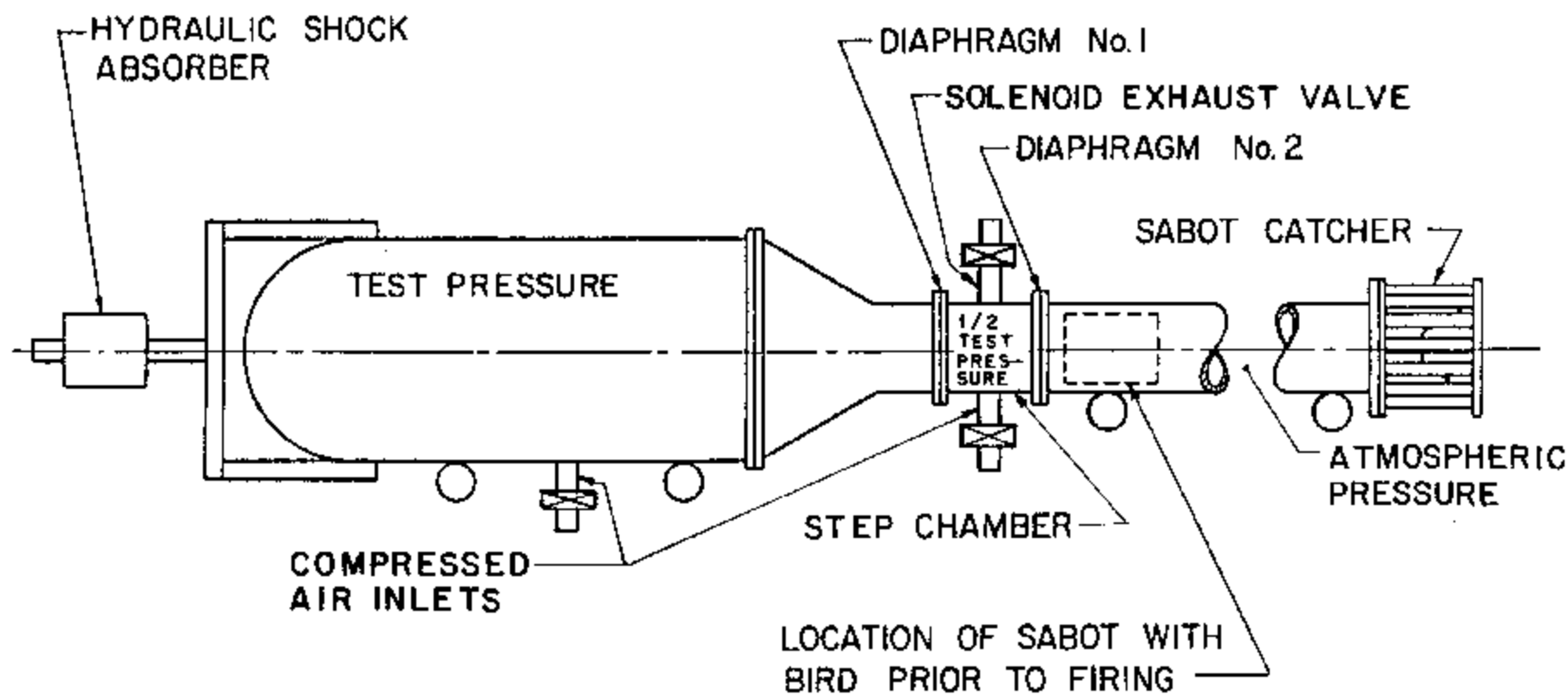


FIG. 3: DIAGRAM OF PNEUMATIC CANNON

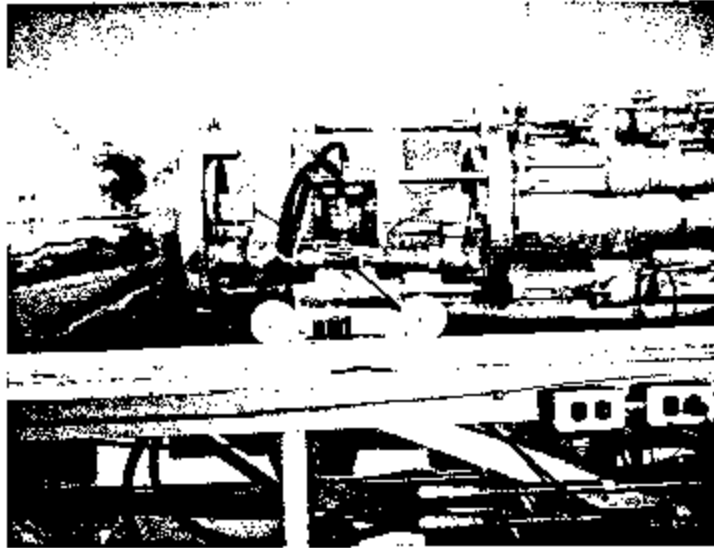


FIG. 4: STEP CHAMBER

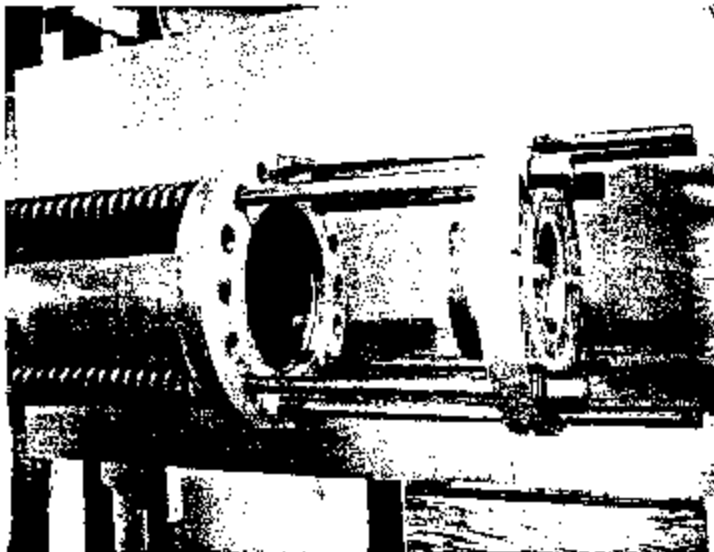


FIG. 5: SABOT ARRESTOR

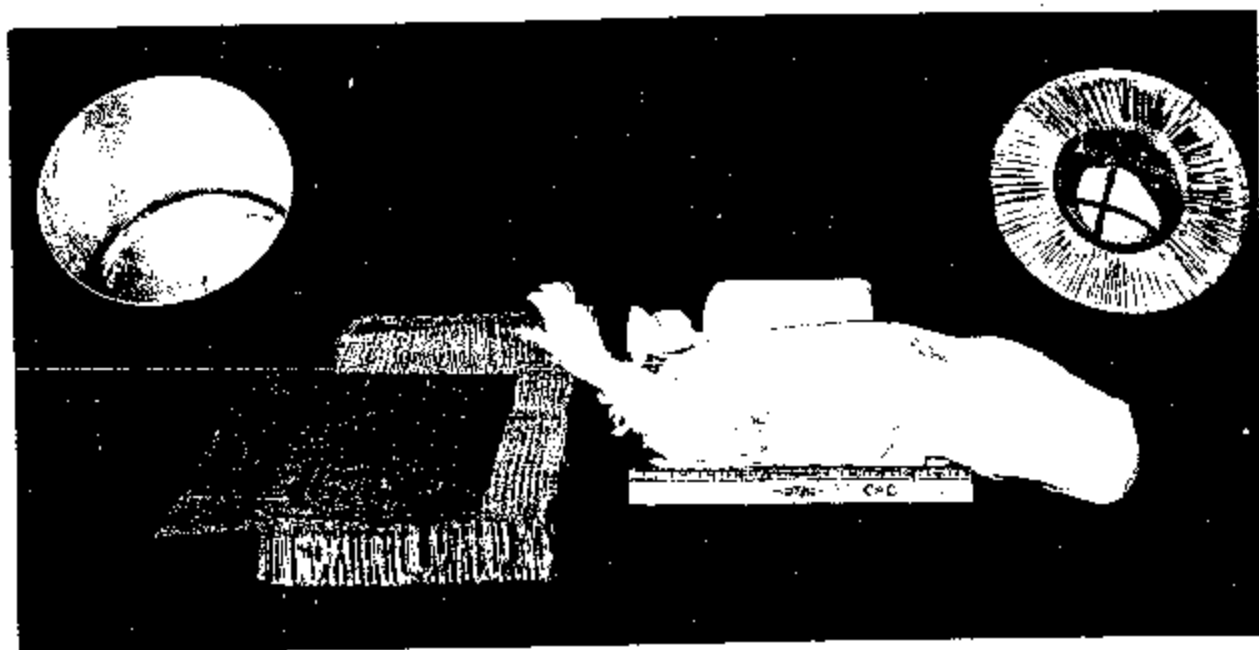


FIG. 6: SABOT COMPONENTS. BIRD PACKAGE AND ASSEMBLED SABOT WITH BIRD PACKAGE READY FOR FIRING

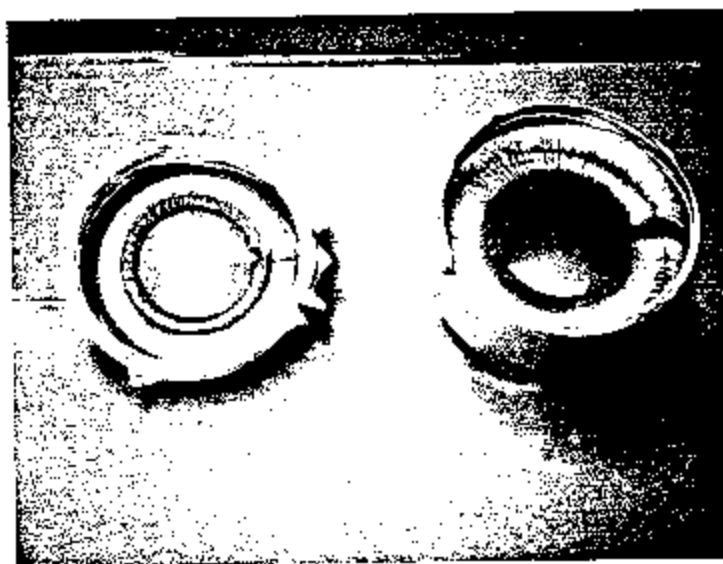


FIG. 7: EXAMPLES OF SPENT SABOTS

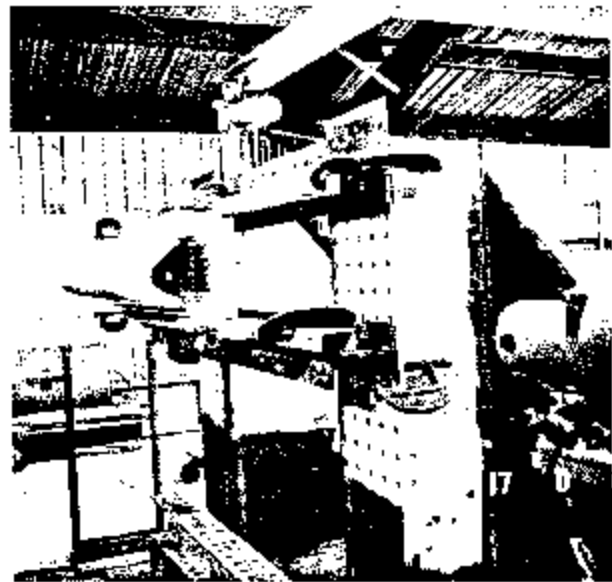
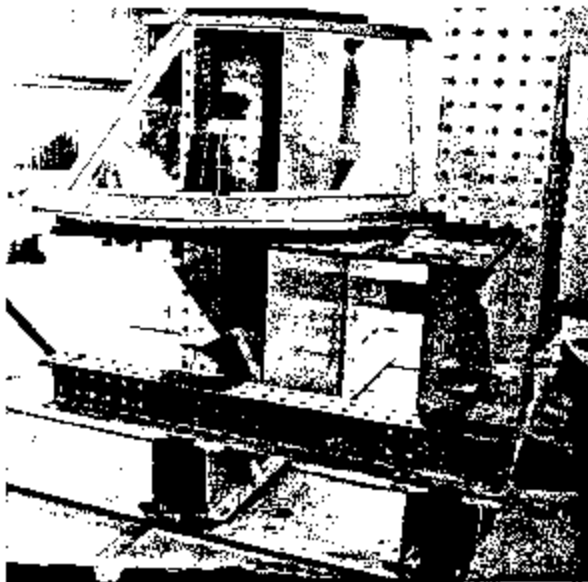


FIG. 8: TYPICAL TEST SET-UPS USING F.I.S. SUPPORT FRAMES

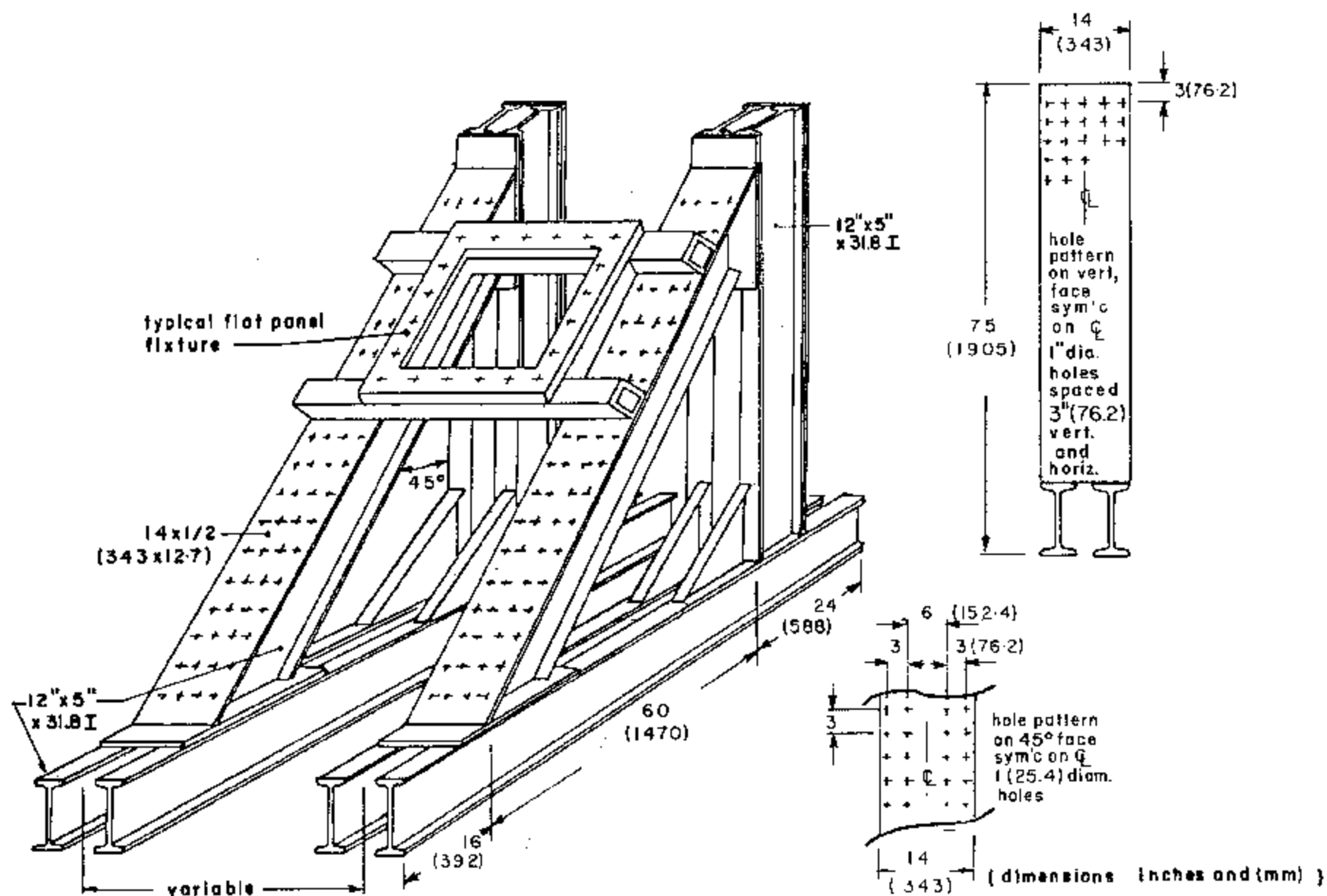


FIG. 9: SUPPORT FRAME



FIG. 10: SWEEPBACK ANGLE APPARATUS IN USE

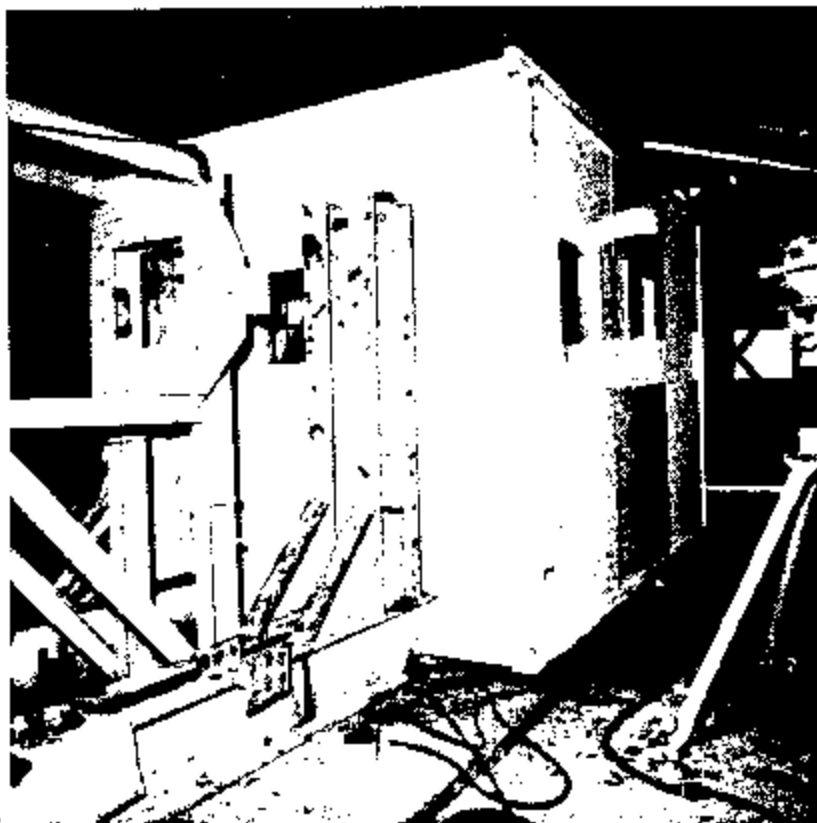


FIG. 11: TEMPERATURE CONDITIONING ENCLOSURE

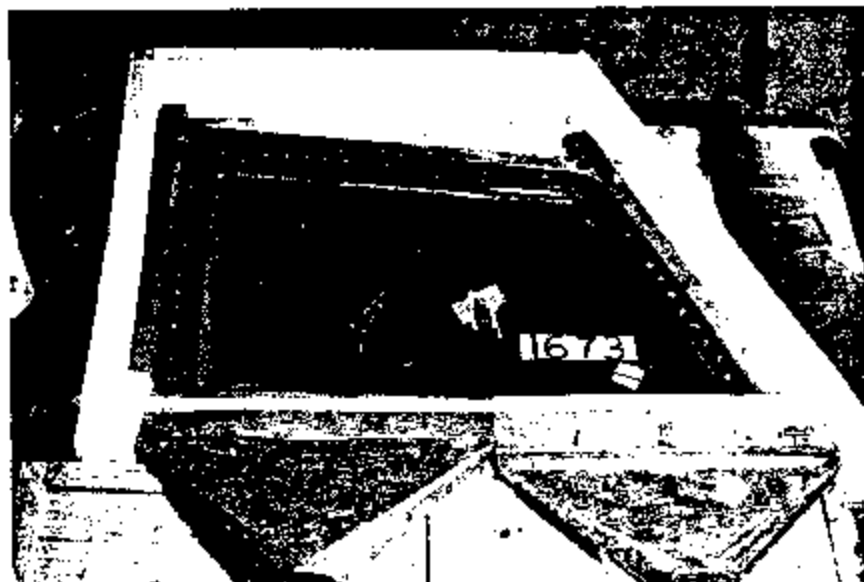


FIG. 12: STYROFOAM ENCLOSURE FOR HIGH OR LOW TEMPERATURE IMPACTS
(COVER REMOVED)

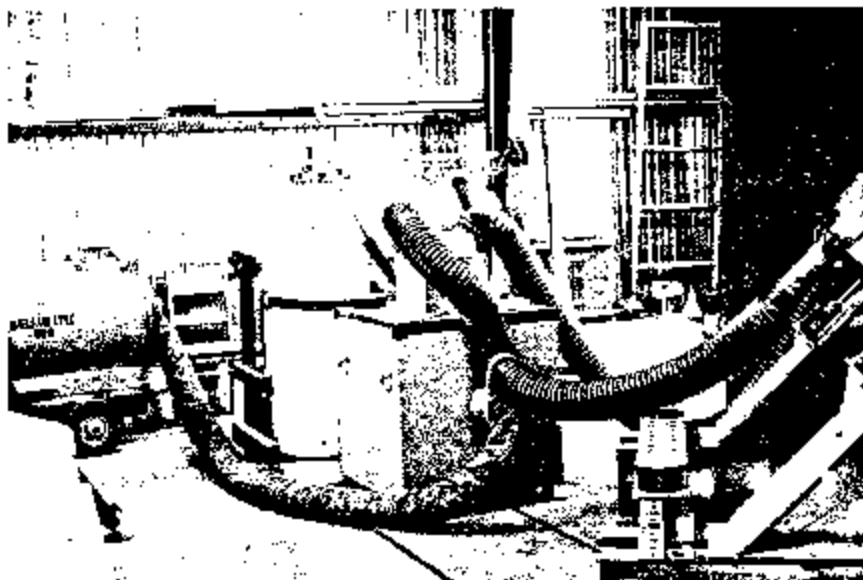


FIG. 13: AIR-LIQUID NITROGEN MIXING BOX

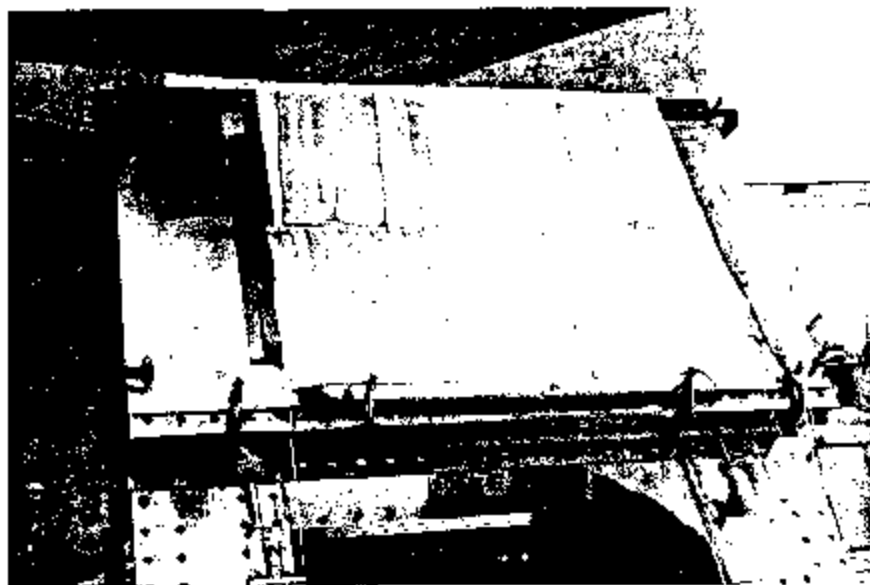


FIG. 14: WINDSHIELD HEATING WITH AN ELECTRIC BLANKET.
INSULATED COVER SHOWN IN POSITION

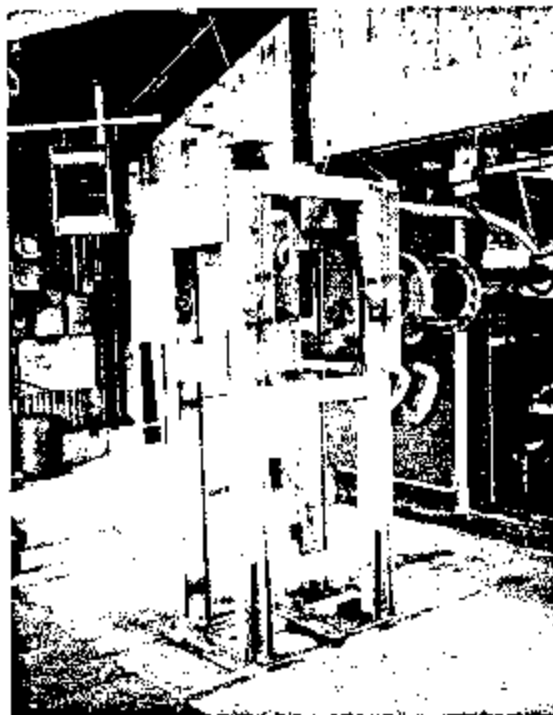


FIG. 15: TIMING FRAME



FIG. 16: DETAIL OF THE THREE "STOP" UNITS

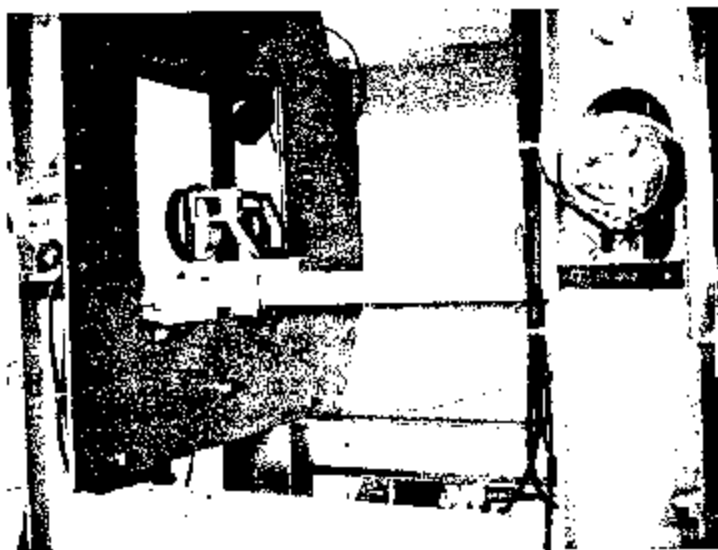
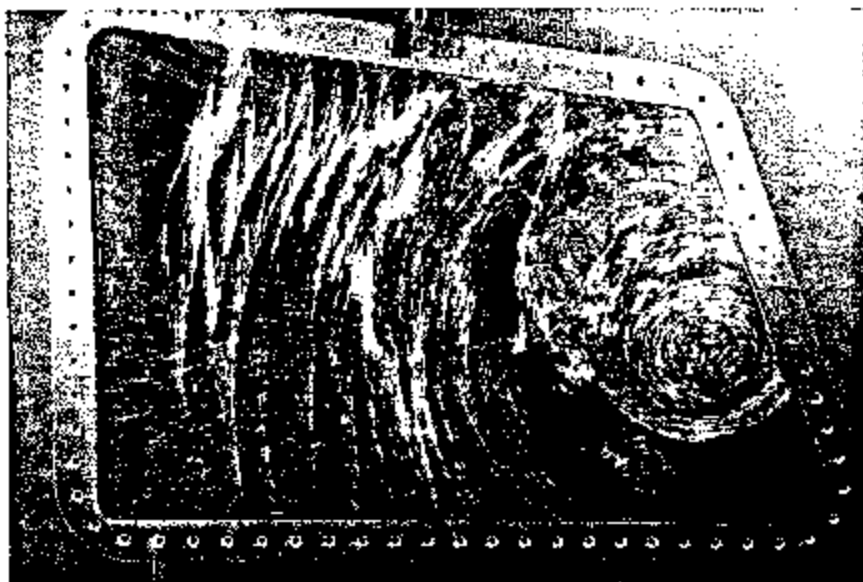
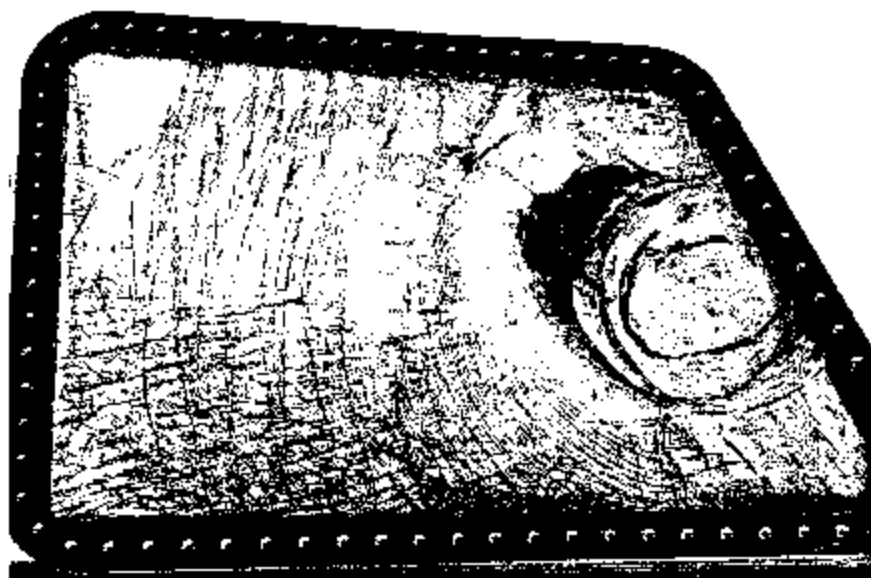


FIG. 17: TIMING INTERVAL APPARATUS SHOWN IN POSITION



(a) WITH FLOOD LAMPS



(b) ON LIGHT TABLE

FIG. 18: DAMAGED WINDSHIELD PHOTOGRAPHY ENHANCED
USING A LIGHT TABLE

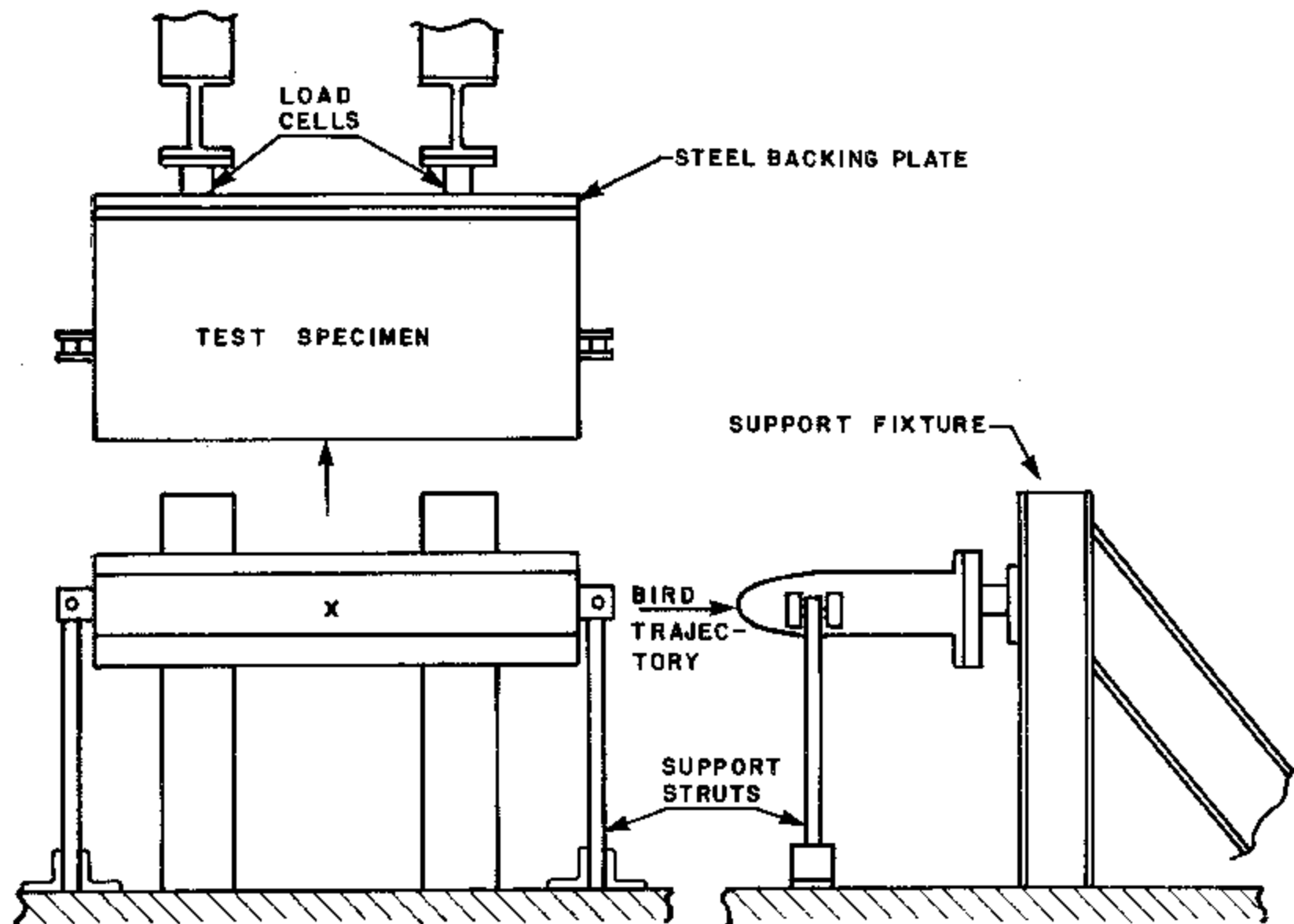


FIG. 19: A TEST SET-UP FOR MEASUREMENT OF PEAK FORCE AND FORCE VERSUS TIME HISTORY

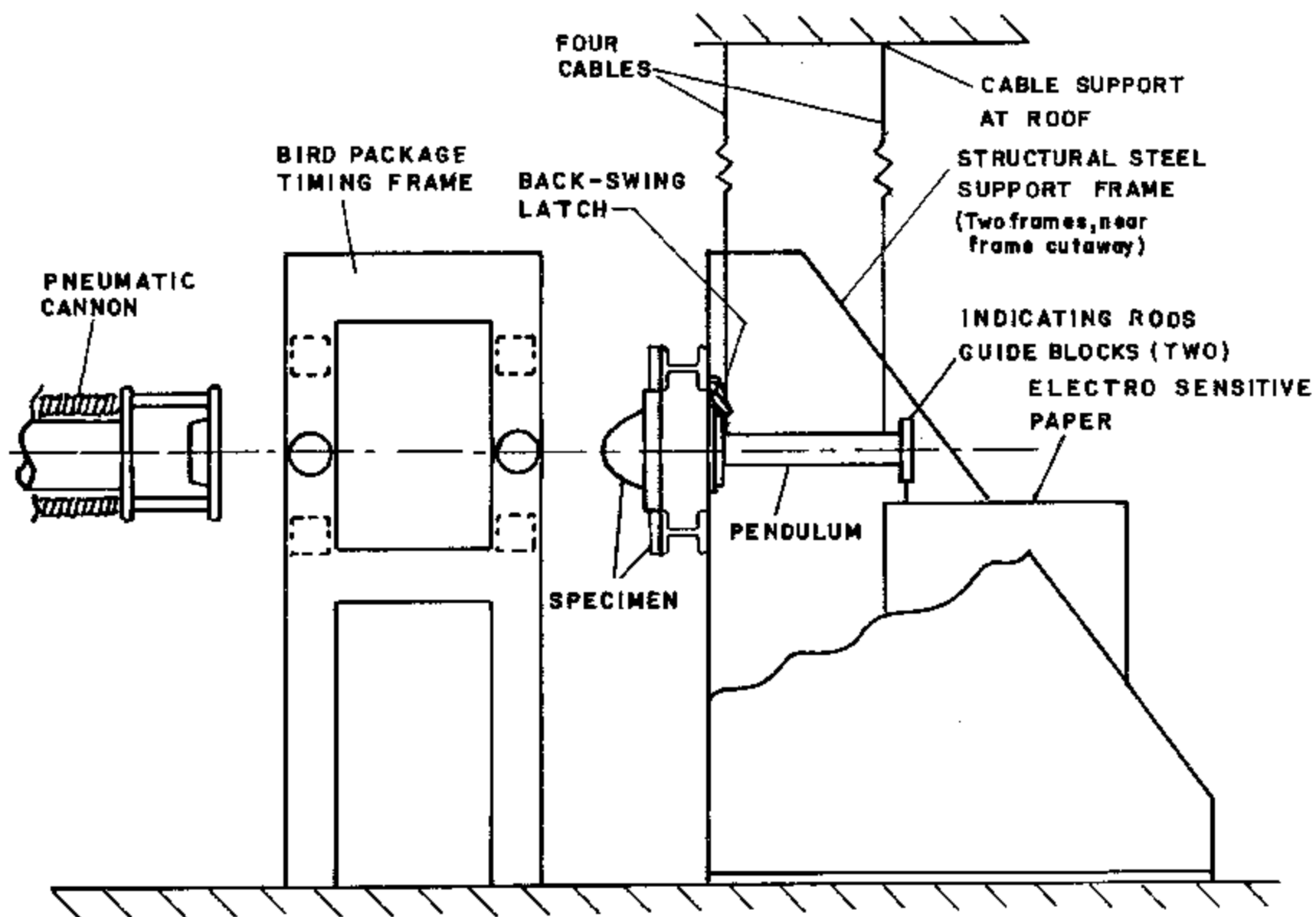


FIG. 20: SCHEMATIC OF BALLISTIC PENDULUM SET-UP

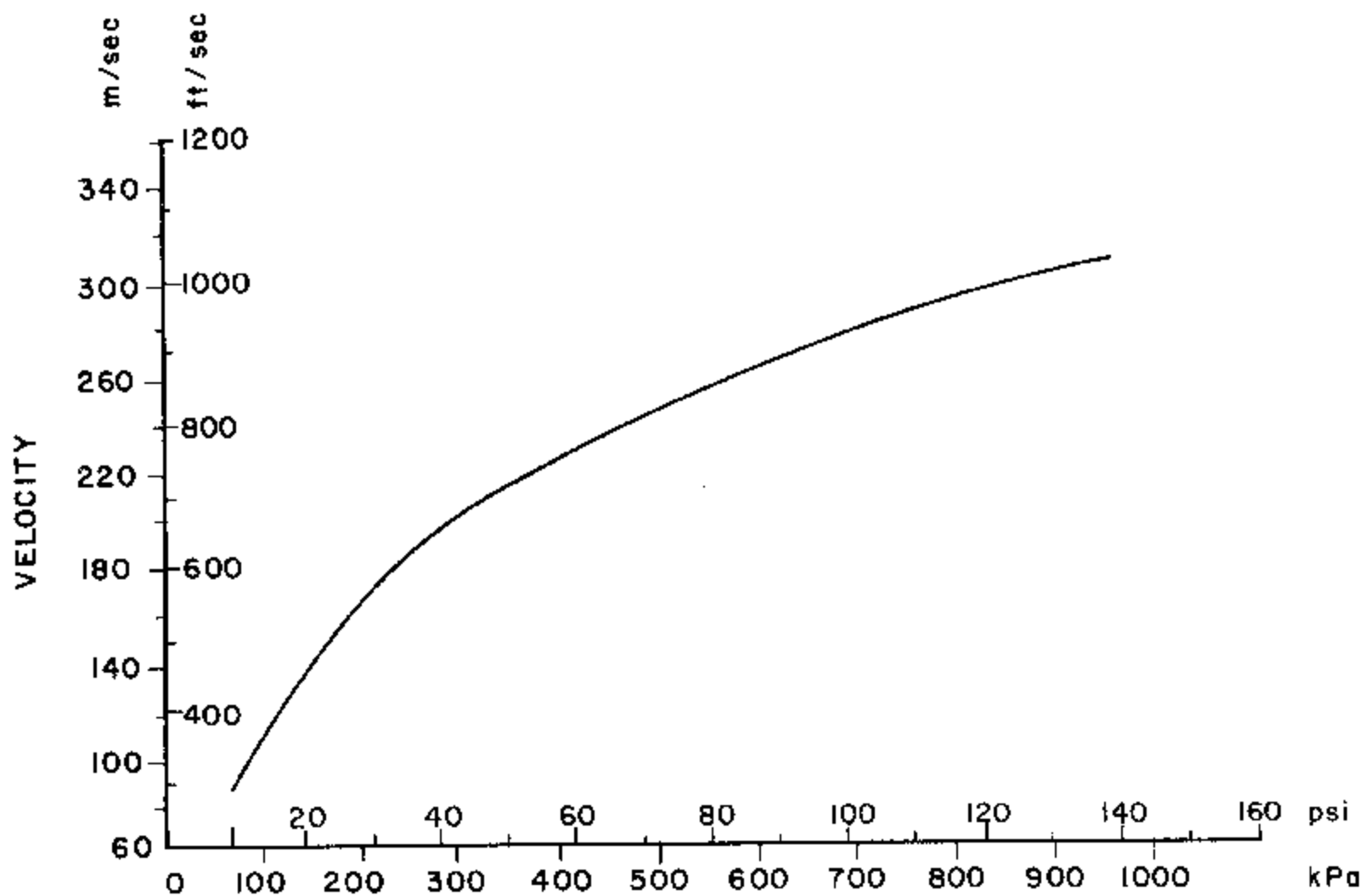


FIG. 21: PRESSURE VERSUS VELOCITY FOR A 1.8 kg (4 lb) BIRD

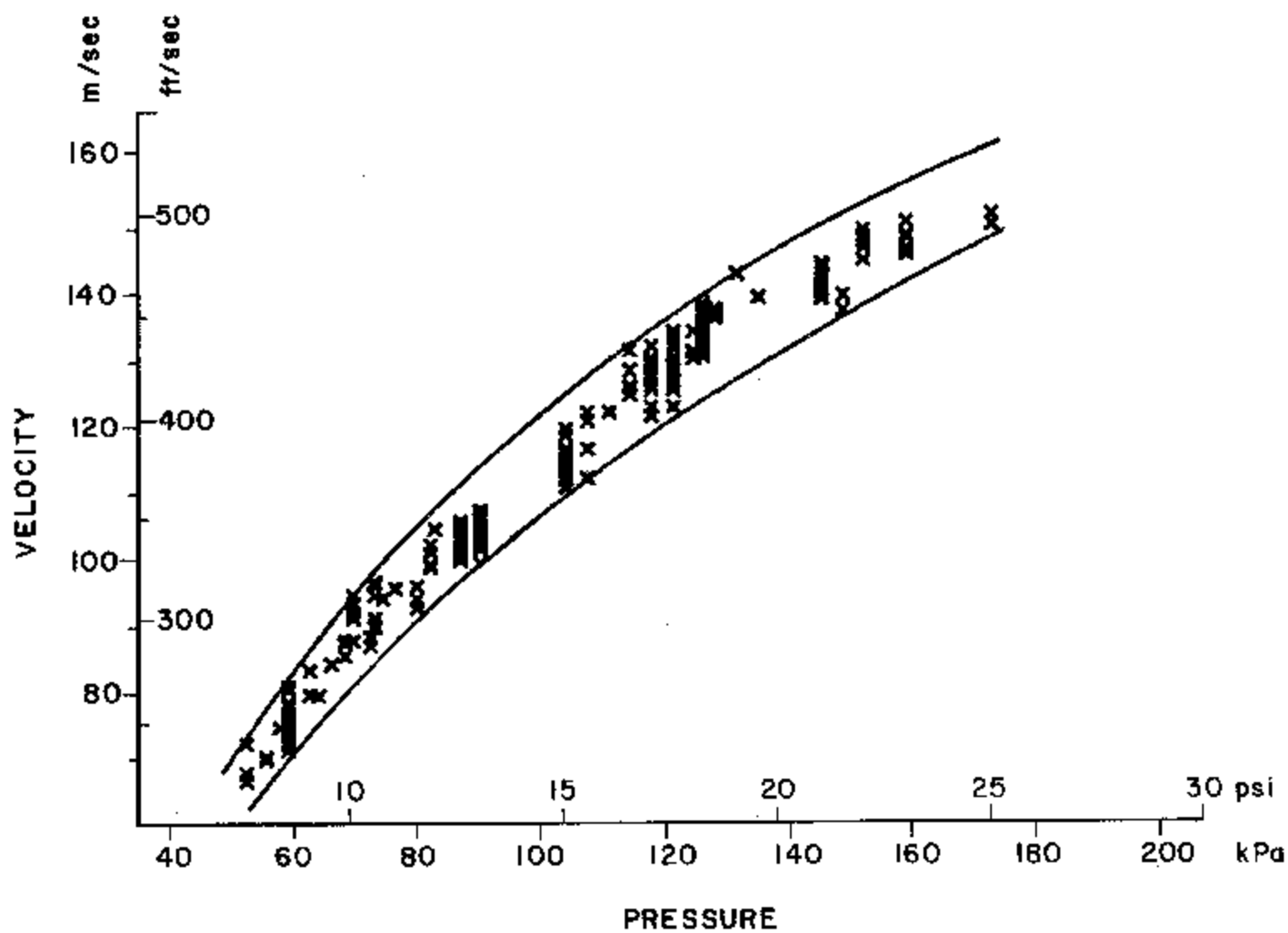


FIG. 22: PRESSURE VERSUS VELOCITY FOR A 1.8 kg (4 lb) BIRD

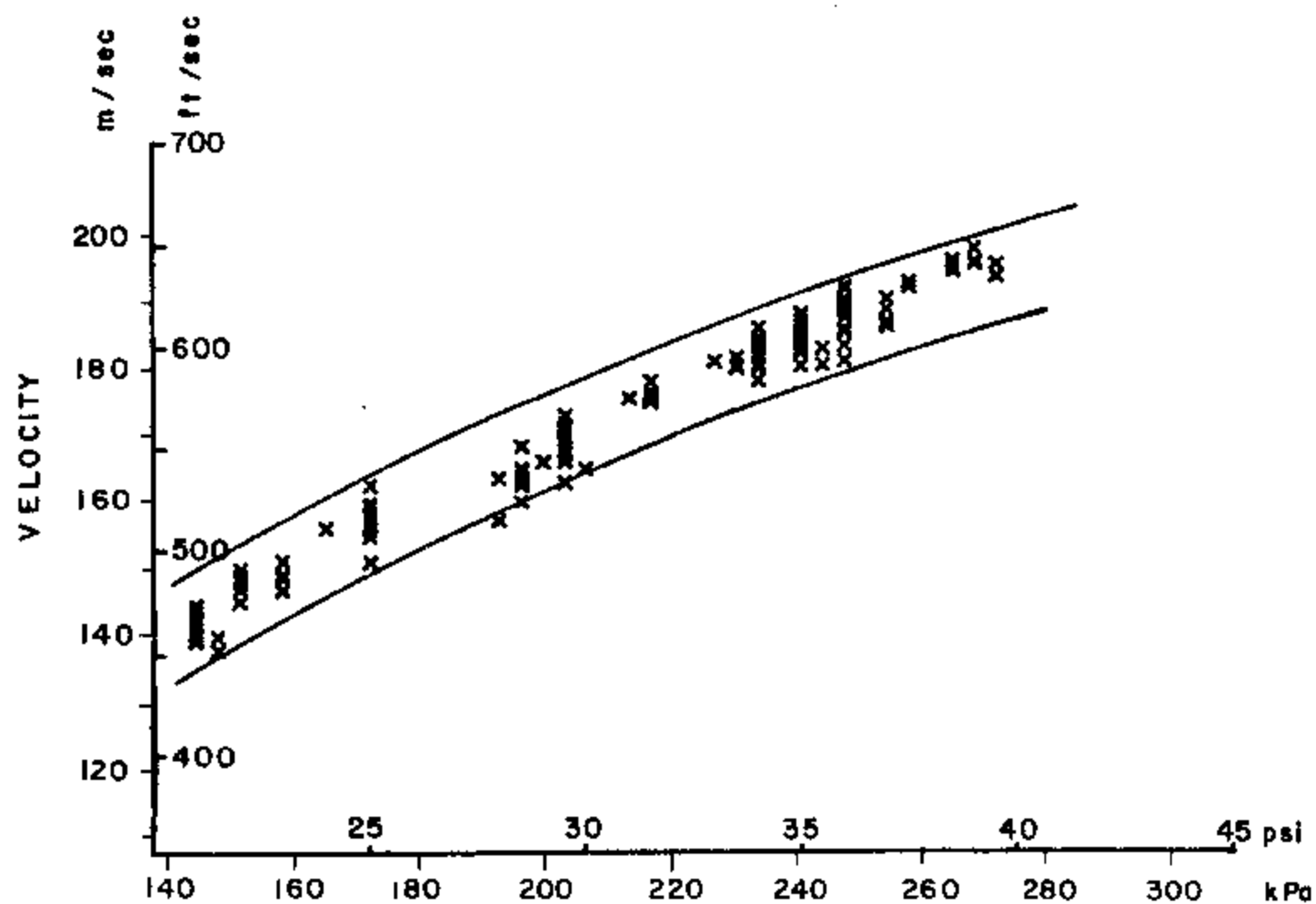


FIG. 23: PRESSURE VERSUS VELOCITY FOR A 1.8 kg (4 lb) BIRD

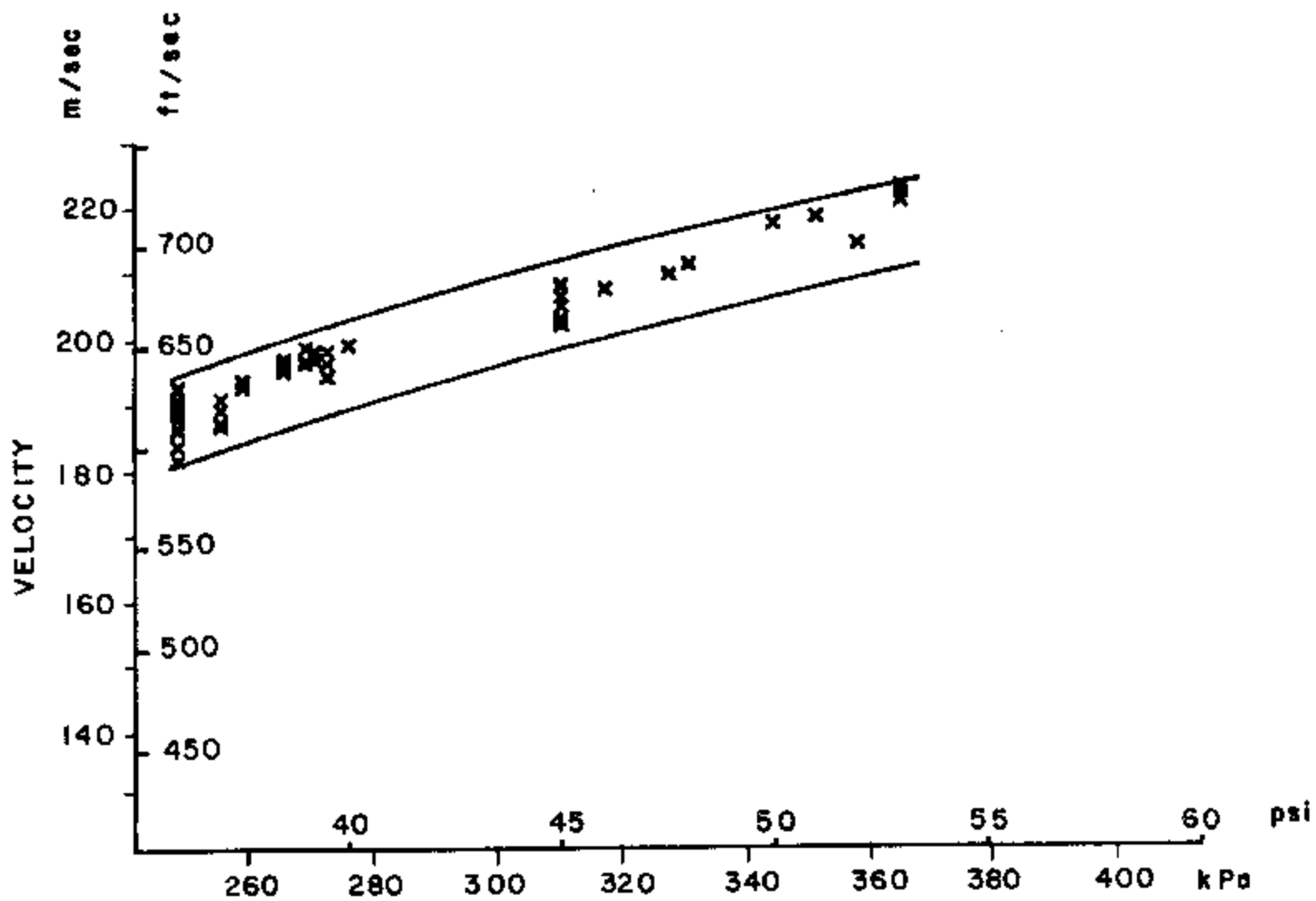


FIG. 24: PRESSURE VERSUS VELOCITY FOR A 1.8 kg (4 lb) BIRD

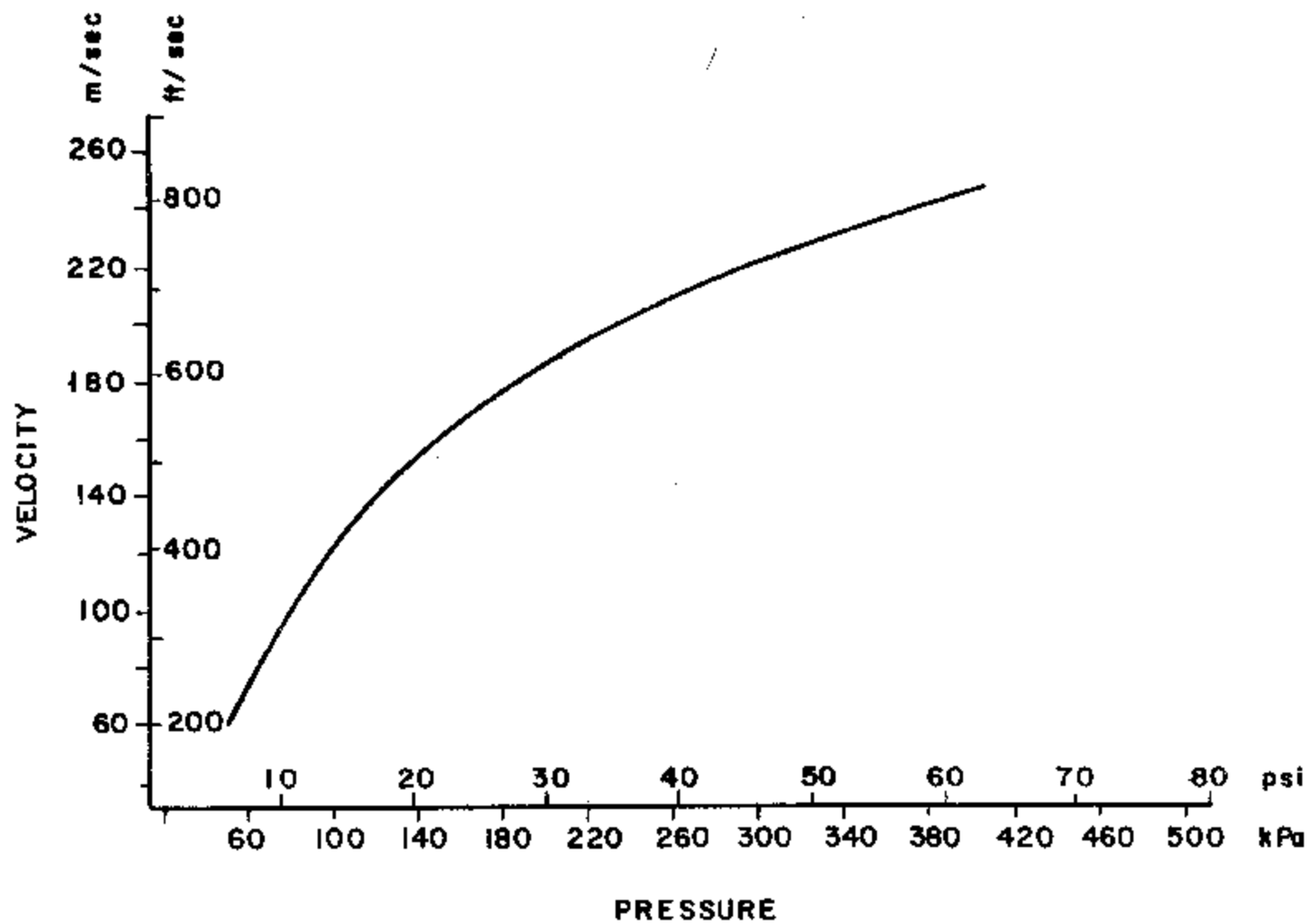


FIG. 25: PRESSURE VERSUS VELOCITY FOR A .9 kg (2 lb) BIRD

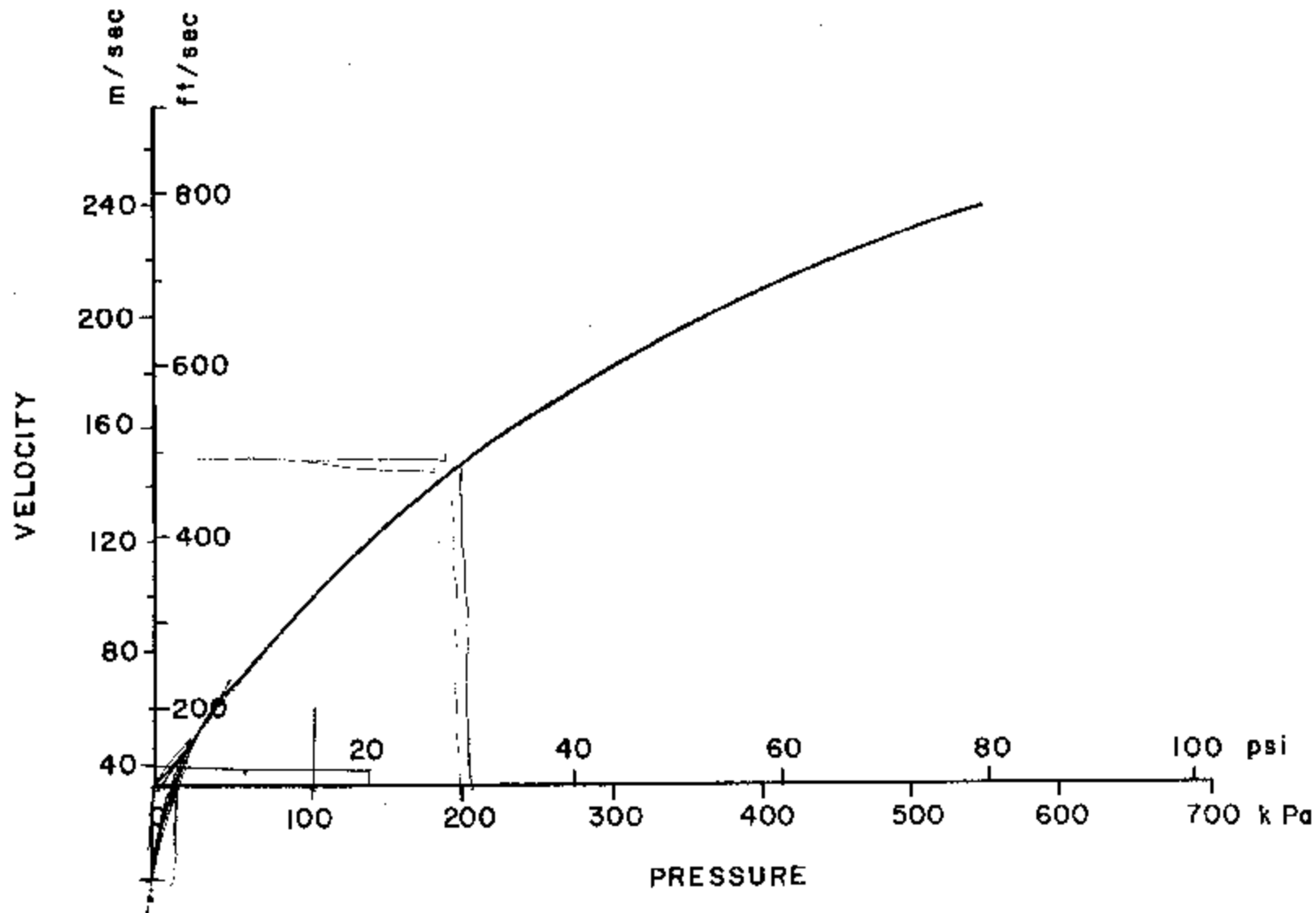


FIG. 26: PRESSURE VERSUS VELOCITY FOR A 3.6 kg (8 lb) BIRD

REPORT DOCUMENTATION PAGE / PAGE DE DOCUMENTATION DE RAPPORT

REPORT/RAPPORT		REPORT/RAPPORT		
1a NAE-AN-13		1b NRC NO. 21379		
REPORT SECURITY CLASSIFICATION CLASSIFICATION DE SÉCURITÉ DE RAPPORT		DISTRIBUTION (LIMITATIONS)		
2 Unclassified		3 Unlimited		
TITLE/SUBTITLE/TITRE/SOUS-TITRE				
4 Capabilities of the NRCC/NAE Flight Impact Simulator Facility				
AUTHOR(S)/AUTEUR(S)				
5 J.B.R. Heath, R.W. Gould and G.R. Cowper				
SERIES/SÉRIE				
6 Aeronautical Note				
CORPORATE AUTHOR/PERFORMING AGENCY/AUTEUR D'ENTREPRISE/AGENCE D'EXÉCUTION				
7 National Research Council Canada National Aeronautical Establishment Structures and Materials Laboratory				
SPONSORING AGENCY/AGENCE DE SUBVENTION				
8				
DATE	FILE/DOSSIER	LAB. ORDER COMMANDE DU LAB.	PAGES	FIGS/DIAGRAMMES
9 83-05	10	11	12a 31	12b 26
NOTES				
13				
DESCRIPTORS (KEY WORDS)/MOTS-CLÉS				
14 1. Flight Hazards 2. Flight Impact Simulator Facility				
SUMMARY/SOMMAIRE				
This report describes the NRCC/NAE Flight Impact Facility in which birdstrike tests on aircraft parts can be carried out. Technical information is given on the capabilities of the pneumatic cannon used to fire real bird carcasses against stationary targets, and on the auxiliary apparatus and instrumentation available at the Facility.				
15				

APPENDIX 19

North American Bird Hazard Reduction Efforts Since the 707 AWACS Accident at Elmendorf, AFB

North American Bird Hazard Reduction Efforts Since the 707 AWACS Accident at Elmendorf, AFB

**Todd Curtis (Student Member ST3927)
Airline Safety Analyst, Boeing Commercial Airplane Group**

On 22 September 1995, a U.S. Air Force 707 AWACS crashed after striking a flock of Canada geese during takeoff at Elmendorf AFB, Alaska. All 24 crew members were killed and the aircraft was destroyed. This accident affected several subsequent efforts on the part of the aviation industry and the governments of the U.S. and Canada to address bird hazard related issues. The accident has not led to fundamental changes in policies and procedures on the part of U.S. or Canadian regulatory authorities, but some of these efforts did lead to additional industry led efforts to address bird hazards. This paper will conclude with a discussion on how the most effective means for reducing the threat from birds and other wildlife is controlling wildlife populations and wildlife habitats in and near airports.

1.0 Ongoing Bird Hazard Efforts Prior to Elmendorf

In the years prior to Elmendorf, birds were a known hazard to both civilian and military aviation communities and there were several efforts in North America and elsewhere to deal with the threat. In addition to the Bird Aircraft Strike Hazard (BASH) team of the U.S. Air Force, there were three organizations, Bird Strike Committee Europe, Bird Strike Committee USA, and Bird Strike Committee Canada which sponsored a number of conferences where representatives from the military, the airline industry, and academia reviewed ongoing research and developments in bird hazard management, bird populations, and aircraft design.

Engine and aircraft manufacturers also contributed by making new aircraft and engine models more resistant to the effects of bird strikes. The 777 engines built by Rolls Royce, Pratt and Whitney, and GE were designed to withstand the ingestion of larger birds and greater numbers of smaller birds compared to earlier engine models. The design of the 777 airframe was more resistant to the effects of bird strikes due to increased separation of flight critical systems and increased protection requirements for those systems. This reduced the likelihood that birds could penetrate the aircraft and disable one or more major systems.

Many major airports with serious bird hazards, such as Vancouver and Toronto in Canada and JFK in New York continued to develop a number of techniques and programs to either reduce the population of larger birds or to keep them separated from aircraft. In the case of JFK, the size and sophistication of their bird control program was partly a result of a bird strike related hull loss accident in 1975 and due to the fact that the airport is adjacent to a wildlife refuge and many thousands of birds.

2.0 Review of the Elmendorf Accident and the U.S. Air Force Response

According to the accident report, about 45 seconds after the aircraft initiated its takeoff roll and just after the beginning of rotation, the aircraft struck a flock of Canada geese, several of which were ingested into engines one and two. There was a total loss of power due to an uncontained catastrophic failure of engine two and compressor stalls along with a 50 to 70 percent loss of power in engine one. This aircraft began a slow climbing left hand turn, but less than a minute later crashed into a hilly wooded area about one mile from the departure end of the runway. The report concluded that the accident was directly caused by the ingestion of Canada geese into engines one and two. It also concluded that contributing substantially to the accident were ineffective efforts to detect and deter geese and a lack of a warning about the presence of geese on the runway infield.

The response of the Air Force was to change several bird hazard policies and to increase the emphasis on avoiding the problem in the future. For example, the Air Mobility Command, responsible for many Air Force transport aircraft such as the C-141, instituted several changes by the early part of 1996 such as creating more detailed definitions of bird conditions that would affect flight operations and formalizing the process by which flight crews, ground crews, and air traffic control deals with hazardous bird conditions. Major Air Force commands are also now required to perform reviews of bird hazard management programs twice a year.

The Air Force's BASH group at Kirtland AFB, NM has had a central role in increasing Air Force awareness after the accident. The group created a bird hazard Web site at <http://www-afsc.saia.af.mil/AFSC/Bash/home.htm> that provides information about bird control techniques, summaries of bird strike effects on Air Force aircraft, and links to Air Force bird hazard management plans. The group has also been involved in the development of a computer based bird hazard management tool that will assist Air Force bases with creating a systematic approach to the problem.

3.0 U.S. and Canadian Government Actions Since Elmendorf

The Air Force, NTSB, and FAA were the U.S. government agencies with the most notable bird hazard reduction efforts after Elmendorf. Transport Canada supported the U.S. federal initiatives in part by completing two projects that significantly enhanced the accessibility of bird hazard information.

3.1 Transport Canada Actions

The two Transport Canada projects involved making educational and informational materials available to the aviation industry and to the general public. They were both begun after Elmendorf and were influenced by the lessons learned from that accident. One project resulted in the June 1997 release of *Crossed Paths*, a video which uses historical information such as the Elmendorf accident and several serious civilian bird strike events to describes many of the general issues of bird hazards from the perspective of pilots, maintenance personnel, and airfield operators.

Even more significant was the launching of a Web site in June 1997 dedicated to providing information on bird strikes. Although the site was aimed at Canadian users, much of the information is applicable to pilots, airport operators, and airlines throughout the world. Available in both English and French, the site is located at <http://www.tc.gc.ca/aviation/wildlife.htm>, and contains the following resources:

1. A wildlife control procedures manual that provides guidance wildlife dispersal methods and information on the kinds of damage that birds may cause to aircraft.
2. Information on avoiding bird strikes.
3. Canadian bird strike statistical summaries from recent years.
4. A bird and wildlife strike report form that can be submitted electronically.
5. Proceedings from the last six meetings of Bird Strike Committee Canada.

3.2 NTSB and FAA Actions

Shortly after the accident, the NTSB brought together a number of representatives from the scientific community, government, and the aviation industry to address hazards posed by large flocking birds in North America. During the briefing, which was chaired by NTSB Member John Goglia, the group was informed about several aspects of the underlying risk:

1. Since 1975, the year of the previous North American bird strike related hull loss of a large jet transport, the North American populations of large flocking birds like the Canada geese had more than doubled and the number of flights by large jet transports had increased by over 50%.
2. The rate of the increase in these populations showed no signs of abating.
3. Due to the success of environmental and conservation efforts of the past 25 years, there are more and better bird habitat areas near airports.
4. Many of the bird habitat areas near airports are often populated by normally migratory species which have become year round residents of that habitat.

The NTSB agreed to develop recommendations for rule changes that would better address current and future safety risks due to bird strikes. In July 1996, the NTSB made five recommendations to the FAA, A-96-38 through A-96-42. All of these issues were closed by April of 1997 with the first two being closed based on previous FAA actions and regulations. FAA actions on the other three recommendations were as follows:

1. A-96-40: issued a notice that directs air traffic managers to ensure that all controllers are briefed annually on the most recent contents of FAA Order 711065J, paragraph 2-1-22, Bird Activity Information.
2. A-96-41: changed FAA Order 711065J, paragraph 2-9-3 to require that the Automatic Terminal Information System (ATIS) contain available information on bird activity.
3. A-96-42: issued Flight Standards Information Bulletin for Air Transportation 96-18 which directs principal operations inspectors to encourage their respective operators to brief pilots and maintenance personnel on the hazards of bird strikes and the need to report all bird strikes to the FAA.

In addition to addressing bird hazards in response to the NTSB recommendations, the FAA published several reports summarizing the bird and wildlife strike data that had been collected over the last several years. The latest report covers the years 1992 to 1996 and is available at <http://www.faa.gov/arp/strkrpt.pdf> on the Web.

4.0 Aviation Industry Initiatives Since Elmendorf

Among the other issues discussed during the NTSB briefing were:

1. Creation of an industry group that would perform a risk assessment for bird strikes.
2. Public awareness of the scope and seriousness of bird strike related problems.
3. Making airport authorities aware of the need for wildlife reduction programs.
4. Encouraging the flight operations and air traffic control communities to change training and procedures so that aircraft reduce their exposure to bird strike threats.

One of groups at the briefing, the Air Line Pilots Association (ALPA), followed up on the briefing by addressing wildlife hazard issues at their annual Air Safety Forum in August of 1996. ALPA convened a panel of experts on wildlife hazards to discuss the scope of the problem and the level of success of those groups that had been addressing those issues. As a result of that first panel ALPA along with Airports Council International, met with a number of representatives of various federal agencies and industry groups the following November and formed the Wildlife Hazards Working Group. The group was formed to complement the previously existing groups like the Air Force BASH team and Bird Strike Committee USA, which were led by the military or government employees and therefore were unable to effectively address some legal and policy issues.

The Wildlife Hazards Working Group's goals were to build upon the research oriented work of Bird Strike Committee USA and Bird Strike Committee Canada and play more of an advocacy role in several areas:

1. Bringing wildlife hazard issues to the attention of airport operators.
2. Encouraging other industry groups to put wildlife hazard issues into their agendas.
3. Analyzing industry data to develop wildlife hazards related risk assessments.
4. Gathering industry support for continued federal funding for wildlife hazard research.

One of the areas where the group has had an impact was in working with the industry group National Aerospace FOD Prevention, Inc. to incorporate bird and other wildlife threats into their ongoing efforts to reduce aircraft hazards due to foreign object damage. The Wildlife Hazard Working Group worked also with National Aerospace FOD Prevention, Inc. to develop a risk assessment for bird strikes in North America. That assessment estimates that in the next 10 years that there is about a 25% chance of at least one bird strike related fatal accident involving a large civilian jet transport in North America. The two groups have also jointly developed a Web site accessible through <http://www.boeing.com/companyoffices/fod/> that contains the risk assessment, background information on the threat of bird strikes, and other information about wildlife hazard research and wildlife control measures.

5.0 Conclusions

The accident at Elmendorf was a dramatic example of the continuing threat that birds pose for large jet transport aircraft in North America. In a way, Elmendorf was an exception to most serious bird related accidents. Between 1978 and 1995, there were six bird strike related hull losses and of those six, only in two cases was the aircraft damaged so severely that it was unable to safely land or reject a takeoff. In the other four cases, none involving aircraft currently in production, the aircraft design dealt with the threat. While retrofits of the current fleet and new aircraft designs can make aircraft more resilient to the effects of wildlife strikes, there are more effective options available.

Significantly reducing the threat from wildlife hazards is possible only by reducing the likelihood of an aircraft encounter with wildlife on or near airports. Making habitats less attractive to wildlife, reducing the wildlife population on or near airports, and altering procedures to reduce the chances of impacts are techniques that are much more effective than relying on new aircraft designs or retrofitting current aircraft. Reducing the overall threat also protects any aircraft that use an airport, not just the large jet transports.

The military has already been able to implement a number of changes in aircraft operations and airfield management that has reduced the threat from wildlife. The Wildlife Hazard Working Group represents one of the best opportunities for shaping similar changes on the civilian side. That group will succeed in its task only if the airport operators and the FAA work together to develop effective means to reduce the populations of the birds and other wildlife that threaten aircraft in North America.

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Biography

Todd Curtis has been an airline safety analyst for the Boeing Company since 1991. He is currently a doctoral candidate at the Union Institute and holds two degrees from MIT, an MBA from the Sloan School of Management and a masters from the Technology and Policy Program. He also holds a bachelors in electrical engineering from Princeton. His major research areas are aviation risk assessment and bird strike hazards to aircraft.

APPENDIX 20

Using the Internet to Support Aviation Safety Research and Education

Using the Internet to Support Aviation Safety Research and Education
Todd Curtis (Student Member ST3927)
Airline Safety Analyst, Boeing Commercial Airplane Group

The Internet has progressed from a tool of specialized researchers and academicians to a world wide medium of mass communication. Two features of the Internet, electronic mail (email) and the World Wide Web (Web), provides aviation safety professionals with a significant opportunity to support aviation safety research and to provide useful information to other safety professionals and the general public.

This paper will address the following subjects and how they affect the aviation safety community:

1. Overview of the Internet.
2. Limitations of email and Web sites
3. Aviation Safety uses of the Web.
4. Content and design issues for aviation safety Web Sites.
5. Case study of one Web site.

1.0 Overview of the Internet

On a physical level, the Internet is a collection of computers and a means to communicate between them. On a social level, the Internet allows widely dispersed groups or individuals to easily communicate with one another. The two parts of the Internet that are most relevant to aviation safety are email and the Web. The Web and email facilitate two kinds of communication, private communication between two people via email or a broadcast type communication between a Web site and an audience.

While basic email messages are written in plain text, some email systems allow the use of formatted text, graphics, or attached files. Web sites are used for communication in ways that are similar to how traditional printed and broadcast media are used. These uses include advertising or promoting products or services, education, public debate, and providing information. While Web sites are often adjuncts of existing businesses or organizations, the relatively low cost of creating and maintaining a Web site has allowed millions of individuals to also have a presence on the Web.

While any site has the potential to reach all Web users, most sites practice some kind of "narrowcasting" where the information on the site is targeted to a very specific audience. Even the sites with significant organizational resources, like those associated with national governments and large corporations, deal with those events and issues that are of concern to the organization managing the site.

1.1 Web Site Characteristics

A Web site is nothing more than a collection of files residing on a computer that can communicate to other computers on the Web. Web sites, unlike email, serve a broad audience. Aviation safety related Web sites, whether developed by a government agency, non-profit organization, private business, or an individual, tend to have many the following characteristics:

- One or more pages, all of which have a unique Web address and which may contain information in the form of text, graphics, sound, or animation.
- A main or home page located at the primary address for the site.
- An overall theme for the information contained in the site.
- One or more links to other Web sites.
- A means for Web users and Web site developers to communicate.

Web sites share many of the characteristics of broadcast media:

- The potential audience is limited only by the technical constraints of the medium and the number of people with access to the medium.
- The marginal cost of accommodating an additional user is essentially zero.
- The content can evolve over time.
- The contents of any work in that medium are subject to copyright protection and other legal protections concerning intellectual property.

Web sites are different from traditional broadcast media in other important ways:

- The costs associated with the creation and maintenance of a Web site are within the means of most individuals and organizations that access the Web.
- The content of a Web site can be enhanced by linking to the content on other sites.
- There is no national or international body which can effectively control what kind of information is on a site.
- Email provides an opportunity for immediate feedback from the user to those who manage the Web site.

2.0 Limitations of Email and Web Sites

Both email and the Web have technical and other limitations that affect the communication and exchange of information. The technical limitations for the most part affect the ability to send or receive information. The other limitations include the lack of privacy in email messages.

2.1 Email limitations

The most important limitation of email is that an email message is not a secure electronic document in that it is possible for people other than the intended recipient to read its contents. Many systems also restrict the size and formatting of email messages. It is possible to overcome the latter limitations by attaching files to the email message. However, not all users have the ability to receive email with attached files. Even if files could be attached, the receiver may not have software that could read those files.

2.2 Web Site Limitations

In a very simple conceptual model of the Web, the Web consists of sending and receiving computers, and a communications network. A person wishing to view the information on a Web site would use their computer to connect to another computer that acts as the host for the Web site, and then retrieve that information to view on their computer. Web sites are affected by three general kinds of limitations: the hardware and software limitations of the user's computer, the hardware and software limitations of the host computer, and the transmission capabilities of the intervening communications network.

The most fundamental limitation is at the viewer end of the system. Web sites are meant to be viewed on either a computer monitor or a television. Sites that contain very long written passages, graphics requiring high resolution, or which contain large audio or motion picture files may not be able to attract and hold the attention of the intended viewer. Also, if a user's viewing software and associated hardware are not compatible, it may be difficult or impossible to see or hear all the contents of a site. The user's system also may not have the capacity for quickly accessing Web sites with large graphic and sound files. To get around this last problem, users often configure their system to initially retrieve only the text portion of a Web site.

Another Web site limitation is the capability of the host computer system. Typically an individual or organization would use some outside party to act as the Web site host. The site may not be accessible when the host system is malfunctioning or shut down and the system may also place limitations on the total size of the files that make up a site. If any site hosted by that computer is very popular, the host computer may not be able to handle the total volume of traffic going to it. Large organizations may provide their own hosting capacity, but similar restrictions would apply.

The communication system that connects the computers of the Internet relies heavily on the telephone systems of the world. While most individual users access the system with a common telephone line, larger users often use dedicated high speed data lines to connect to the Internet. The communication system is limited by the capacity of the network to handle Internet related traffic as well as the traffic due to voice and non-Internet data transmissions. Systems limitations are especially critical in smaller countries where there may be few high speed data connections either within the country or between the country and the outside world.

The following general limitations and realities must always be kept in mind when dealing with information from the Web:

Legal standing: information contained in a Web site, even one managed by a government agency, should not be considered the official or legal version of that information.

Verification: any information on the Web should be independently verified if it is going to be used as the basis of research, risk assessments, decisions, or policy making.

Longevity: information on a Web site can be changed, moved, or eliminated at any time and without warning.

Detail: most information on the Web represents a summary of some larger, more complete body of knowledge.

Standards: there are no universally accepted set of standards for the content, format, or organization of any information on a Web site.

3.0 Aviation Safety Uses of the Web

By late 1997, many aviation safety related Web sites were in operation around the world. There is no accurate census of how many of these sites were active, but the sites that do exist tend to fall into a number of broad categories:

- Government organizations responsible for some aspect of aviation.
- National and international non-profit aviation and aviation safety organizations.
- Aviation related businesses.
- Organizations representing aviation related professions.
- Academic departments, research organizations, or individual researchers.
- News media.
- Private individuals.

The reasons that any individual aviation safety Web site exists are varied, but tend to be in one or more of the following categories:

- Providing information to the general public.
- Advertising or marketing a product or service.
- Providing information about professional, scientific, technical, labor, or academic organizations and events.
- Expressing opinions about aviation safety related topics.
- Providing a public forum for the discussion of ideas, events, and issues.
- Publishing research findings.
- Discussing or analyzing recent aviation accidents.

The kind of data on aviation safety Web sites reflects the interests of the owner of that site. For example, the Air Accidents Investigation Branch (AAIB) of the United Kingdom Ministry of Transport at <http://www.open.gov.uk/aaib/formal.htm> includes the complete contents, including graphics, of the reports associated with recent accidents and incidents investigated by that organization. Other sites, like the privately operated Aviation Safety Web Pages of Harro Ranter at <http://web.inter.nl.net/users/H.Ranter/> contains accident data from around the world but has much less accident detail.

The quantity of information on a Web sites varies widely. The sites run by governments have the widest variety of information. For example, the Transport Canada site at <http://bst-tsb.gc.ca/english.html> contains accident reports, safety studies, and even an airport wildlife control manual. The NTSB site at <http://www.nts.gov> has synopses of over 38,000 aircraft accidents and incidents as well as safety recommendations and recent press releases. In general, non-government sites have a more narrow focus, although some like *Landings* at <http://www.landings.com> has original material or links to outside material covering dozens of aviation safety related topics.

The quality of the information on all aviation safety Web sites depend on the accuracy, timeliness, and coherence of the information as well as how the information is organized and displayed on the site. The quality of a site is also dependent on how well a site meets the needs and expectations of the user and how effectively the developers of that site deal with the limitations and the advantages of using the Web.

4.0 Content and Design Issues for Aviation Safety Web Sites

Web sites are a form of media which combines text, graphics, and sound in a very structured and formal environment. In order to build an effective site, it is necessary to design a site that works well within that environment. The most important part of the development process is to create an overall plan for the contents of the site that would at least address the following areas:

1. Purpose of the site.
2. The needs and desires of the intended audience.
3. Site management.

4.1 Purpose of the Site

Defining the site's purpose or mission may take a very small amount of time and energy or a very large amount depending on the individual or organization developing that site. However, once the definition process is complete, the purpose of the site should be something that is clear and unambiguous to both the developers and the potential audience. If the basic purpose can't be stated in a single sentence or brief paragraph, then it is very likely that the site as a whole will lack a clear focus.

The purpose of the site would also help define what the long term goals of the site may be. In the course of achieving those goals, the site may go through an evolution that may completely change the nature of the site. Site developers should consider the following issues to make sure that this process is both orderly and does not lead to the site losing its focus and direction:

- Changing the range of topics covered in the site.
- Changing the amount of detail in a particular topic.
- Changing the organization of information on the site.
- Changing the site to increase the number of visitors.
- Changing the level of sophistication of the site's contents.
- Coordinating the Web site with other activities.
- Tailoring the site to different audiences.

4.2 The Needs and Desires of the Intended Audience

Knowing what constitutes a useful or compelling Web site is an essential ingredient in designing a Web site. If the information in a proposed Web site is successfully used or provided in some other context, then it is reasonable to expect that it would be successful on a Web site. However, one should answer several questions before putting the information on the Web:

- Are the current users of the information likely to use the Web to access the same information?
- Will the information be presented in ways that are significantly different from how the same information is currently presented?
- Will the information be at least as useful to the potential users on the Web as it is for the current users?

If the information has never been presented before in any medium, other questions would have to be addressed:

- What are the characteristics of the expected audience
- What are the information needs of the potential audience?
- Has similar information ever been presented successfully on the Web?
- Has similar information ever been presented successfully in another medium?

4.3 Site Management

In order to keep a Web site functioning, some individual or group has to manage all aspects of the site from the planning stage onwards. Whether the site an individual endeavor or the product of a large organization, the following tasks must be accomplished:

1. Initial planning.
2. Choosing an address for the Web site.
3. Choosing and managing a host computer for the site.
4. Acquiring the resources for creating the contents for the site.
5. Creating, testing and evaluating the contents of the site.
6. Putting the site into operation.
7. Updating the site's contents and responding to user feedback.
8. Advertising the presence of the site.
9. Coordinating the site with other activities.

The second task, choosing an address, is an activity that can have a long term effect on the success of the site. All Web site addresses have the form `http://site_name`. A Web site developer has some control over the name associated with the main page of the site. One can either use a name assigned by the organization that controls the host computer, or one can purchase the rights to use a specific site name. The biggest advantage to using a specific site name is that the name can be chosen so that the address is easy for users to remember. Two examples are `http://cnn.com` and `http://www.alaska-air.com`.

Over the long term, the seventh task is probably the most important. Web sites exist to serve some audience and some kind of two way communication is necessary in order to effectively improve the site. This communication can be in the form of comments, questions, or requests from either the users or the site's developers and managers. Email is the most convenient method for this kind of communication. At the very least, email links should be provided for the site's users at one or more places in the site.

5.0 Case Study of One Web Site

Much of this author's insights about the aviation safety related Web sites and the Web development process are a direct result of having created and maintained such a site, *AirSafe.com*, formerly known as the *Air Safety Home Page*, over the last 18 months. This case study will discuss the site's initial design and development process, early advertising efforts, modifications to the site, and site usage.

5.1 Site Design and Early Development

The initial design of the site as well as the content of the site was driven by the site's intended purpose and initial goals. The site's stated purpose was to provide airline safety information for the airline passenger. There were several other goals which were chosen to support the site's primary purpose:

- Address aviation safety and risk questions commonly posed by passengers.
- Concentrate on those events that lead to passenger deaths on airline aircraft.
- Use only publicly available sources as reference material for the site.
- Provide an historical perspective of fatal passenger events by aircraft model.
- Allow the most rudimentary user systems to view any area of the site.
- Limit the size of all the pages in order to speed up access to the site.
- Encourage user questions, suggestions, and comments about the site.
- Provide links to related information on the Web whenever appropriate

The resulting site was almost entirely text based and consisted of several distinct sections. Two sections listed recent fatal events in the world and fatal events involving U.S. carriers or occurring under U.S. jurisdiction. Other sections covered areas such as frequently asked aviation safety questions, safety suggestions for the individual traveler, and links to related Web sites.

5.1 Early Advertising Efforts

After activating the site, generating interest in the site and attracting more users was a high priority. This was done in three ways:

1. Registering the site with a number of search engines - Web sites that serve as searchable databases for locating Web sites on specific subjects.
2. Informing several aviation reporters about the existence of the site.
3. Informing a number of aviation safety professionals about the site.

Two events were key for expanding the number of users accessing the site. One was the acquisition of the address name <http://airsafe.com> for the site's home page, and the second was the crash of TWA flight 800. That accident happened about two weeks after the newly named site became operational. Traffic increased by a factor of twenty on the day after the accident as users around the world were searching for sites related to aviation safety. Subsequent to that accident a number of news organizations, including the Web versions of the New York Times and the Washington Post, provided links from aviation safety related articles to the *AirSafe.com* site.

After July, traffic also increased, though not as dramatically, after events such as airline accidents, a major FAA announcement about the expansion of their aviation safety information on their Web site, and media appearances by former DOT inspector general Mary Schiavo that were associated with the release of her first book. In addition to media generated interest, there were many other Web sites, usually related to airline safety and airline travel, which had links to the *AirSafe.com* site.

5.3 Site Usage

The site began initial trials in March of 1996 and in July the site went fully operational with a change of Web address and the addition of several new sections. Traffic highlights from July 1996 to August 1997 are as follows:

- From July 1996 to August 1997, there were been over 400,000 visits to some part of the site with over 70,000 visits to the site's home page.
- The most site visits in a single day was about 7200 on 6 August 1997, the day after an accident involving a Korean Air 747 in Guam.
- Days with a significant increase in traffic over the previous day have been most often associated with accidents involving passenger fatalities on large jet airliners.
- Monthly visits have ranged from 8500 in July 1996 to over 90,000 in August 1997.
- Site visits increased by about 20% per month from July 1996 to February 1997 before leveling off between February and July and more than doubling in August 1997.
- The rate of visits to the site reaches its maximum at around four in the afternoon and its minimum at about four in the morning in the time zone of the eastern U.S.
- Approximately 20% of all the visits originate outside of the U.S.
- Visits from outside the U.S. are most likely to originate in Canada, the United Kingdom, Australia, and Japan.
- The home page is the most visited page on the site and the second most visited page has about 15% of the visits of the home page.
- The most frequently visited pages are those associated with fatal passenger event records of specific airlines and the fatal event records of specific aircraft models.

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- (1) T. Curtis, *AirSafe.com*, a Web site located at <http://airsafe.com>, created March 1996.
- (2) T. Curtis, "Using the World Wide Web for Bird Strike Hazard Awareness," Presentation at the 25th Meeting of Bird Strike Committee Canada, Ottawa, Canada: 6 November 1996.

Biography

Todd Curtis has been an airline safety analyst for the Boeing Company since 1991. He is currently a doctoral candidate at the Union Institute and holds two degrees from MIT, an MBA from the Sloan School of Management and a masters from the Technology and Policy Program. He also holds a bachelors in electrical engineering from Princeton. His major research areas are aviation risk assessment and bird strike hazards to aircraft.

APPENDIX 21

ARFF Hot News

ARFF HOT NEWS:

November 24, 1997 - Plane Crashes in Honduras, Twelve Injured

TEGUCIGALPA, Honduras - Twelve people were injured, four of them seriously, when a light plane crashed near a football field in the north of Honduras Monday, emergency services said.

Robert Stanley, fire brigade officer in La Ceiba, about 120 miles north of the capital Tegucigalpa, said the plane's right engine caught fire and exploded after striking a bird.

"The plane crashed on landing," he said, adding that the craft was 70 percent destroyed.

Three passengers and the pilot were rushed to a hospital in La Ceiba with serious injuries, he said. Eight other passengers on board suffered cuts and bruises.

Stanley said the plane, licensed to carry a maximum of 19 people and operated by Honduran airline Rolling Air, was headed toward the tropical Caribbean island of Roatan but bad weather had forced it to turn back.

After the engine caught fire, the pilot came down on open ground before the plane could reach La Ceiba airport.

More ARFF HOT NEWS:

January 2, 1998 - Bird Smashes Window Of Helicopter

PORT MORESBY, Papua New Guinea - A bird smashed into the window of a helicopter ferrying Australia's foreign minister to Bougainville island today, forcing an emergency landing.

Alexander Downer was taking the twin-engined Bell 212 to the remote island's northeast coast when the bird hit the cockpit window, pilot Steve Burgess said.

Nobody was injured, and the helicopter landed safely in the jungle village of Wakunai.

Downer was to meet with leaders of the island's secessionist forces and Australian soldiers, who are overseeing a cease-fire between the rebels and Papua New Guinea forces.

APPENDIX 22

New tipping fees at the Robin Hood Bay dump to increase 92 percent

The Evening Telegram TeluCentre

TODAY'S TOP NEWS

for Friday, November 28, 1997

Dump tipping fee to increase 92 per cent 11/28/97 ()

By BERNIE BENNETT

The Evening Telegram

New tipping fees at the Robin Hood Bay dump are about to hit commercial customers.

The fees will almost double starting in the New Year and those who will have to pay the shot can only blame it on the seagulls.

Newfound Disposal Systems Ltd. send out a memo Thursday to customers advising them that the tipping fee will increase 92 per cent from \$12 to \$23 per tonne as of Jan. 1.

Pat Short, president of Newfoundland Disposal, explained that as a garbage hauler licensed by the City of St. John's they are required to collect the increased charges on behalf of the city.

He said they will pass the increase on to their customers, the business establishments in the St. John's area, to cover the increase.

"I know this is not good news but it is unavoidable," said Short. "I just want to keep our customers informed of what's happening, but I'm only the messenger."

The increase comes as a result of St. John's City Council being pressured to get control of the ever-increasing seagull population at Robin Hood Bay.

The pressure comes from Transport Canada and the danger the gulls are creating to planes in and out of St. John's airport.

The gulls' flight path to and from their favorite feeding ground, the dump, crosses the runways at the airport and that's where the danger lies. A gull sucked into the engine of an aircraft can bring a plane down, and although there haven't been any disasters yet, there have been reports of close calls.

The city had a study done on ways to control and reduce the seagull population at the dump and the best solution was to cover the garbage as quickly as possible.

The city awarded a \$586,500 contract to BCL Construction Ltd. to cover the fresh garbage as it's brought in and dumped.

And that cost is being passed on with doubled tipping fees to those companies who use the dump.



It will soon cost this truck and others like it more money to dump their garbage at Robin Hood Bay. Tipping fees will increase from \$12 to \$23 per tonne as of Jan. 1.

Other Articles:

Nurses offer contract proposal [November 28 1997]

[Click to View](#)

[All Stories - Text Only](#)

APPENDIX 23

Who Rules the Skies?

November 14, 1997

MAGAZINE

Chapter
14

An F-15 fighter jet
can fly 1,450 kilometers

A seagull with a wingspan of 1.5 meters, can
fly 50 kilometers per hour and can
down an F-15 with its wing

WHO RULES THE SKIES?

Wings of Destruction

New strategies are being planned for a battle being fought in the skies over Israel between man and nature that causes costly damage and claims too many lives.

By Amy Klein

On the day 12 soldiers were killed in Lebanon, September 5, an Air Force F-16 was flying low over the northern Negev craters of Mitape Ramon during exercises. It was just after 2 p.m. that Capt. R. and Sgt. Lt. G. ejected from their plane. Both pilots survived the parachute jump. R., who reached the ground in moderate condition, eventually recovered, and G., who had just completed the pilot's course, was seriously injured. He eventually lost a leg.

The \$27 million F-16 — one of 250 fighter-jets considered a mainstay of the IAF — was totaled.

The charred remains of the plane were gathered by the IAF and given to a special investigation committee. The interim report released September 24 confirmed the preliminary findings: a bird broke the canopy over the cockpit, causing the crash.

The accident was not the first bird-plane collision, or bird strike, that the Air Force has suffered. In the last 25 years alone there have been 3,092 bird strikes, causing dozens of casualties and hundreds of millions of shekels in damage.

The Israel Air Force has the reputation of being one of the best. Since 1948, it has lost only 22 planes in air-to-air combat. On the other hand, eight planes — more than one-third of those lost in combat — were destroyed because birds collided with them. The September accident proves that, despite preventive measures taken in the past decade, the one foe



Remains of an F-16, which crashed in the Judean desert in 1988 after colliding with an eagle. (Below) Some 500 million birds pass through Israel each migration season.



Despite the frequency of severe bird strikes and damages estimated at \$500,000 a plane, the only thing the Air Force did was remove the birds from the runway, says Yossi Leshem.

Though the public believes that bird strikes are an inevitable occurrence, there is a solution in precise radar and monitoring networks, which can provide early warnings to planes.

Main Migration routes of soaring birds over Israel and the Palestinian Authority

- ⊕ Proposed Palestinian Migration Birdwatching centres
- Proposed Israeli Migration Birdwatching centres



IAF pilots are powerless against birds who share their air. And they are no small headache. Birds pose a problem for military and civilian aircraft worldwide, but it is a particularly severe problem in Israel, where about 500 million birds pass each migration season. As the crossroads of three continents, the state is on the route for birds migrating southward from Europe for the winter and returning for the summer. There is a higher concentration of birds here per square kilometer than in any other country. And while that may be a boon for birdwatchers, nature lovers and environmentalists, for Air Force pilots flying at high speeds and low altitudes, it can mean a dangerous ride.

Picture this: A three-kilo stork flies into an F-15 traveling at 1,000 kilometers per hour. The bird is not detectable by regular radar, and the plane is going so fast that its course cannot be changed. The force of the stork smashing into the F-15? Forty tons. A pelican hits an F-15 with the force of 100 tons. It's strong enough to shatter the glass of the cockpit, destroy a wing or mangle an engine, resulting in the loss of a plane – and sometimes a life.

The most recent fatality was two years ago, when an F-15 crashed in the Negev desert because a stork got caught in the engine, throwing the plane off balance and into the ground. The airmen, lieutenants Ronen Lev and Yaron Vlivants, were killed.

Once the 'bird plow zones' were identified, the Air Force had a clear solution: stop flying there.

The loss of life and entire airplanes is a serious aspect of the problem, but only part of it. Injured airmen need treatment and damaged planes must be repaired. (Most armies, for insurance purposes, only report 15 to 20 percent of bird strikes, and they also only take into consideration the "accounting" cost of the damaged plane, not the "economic" ones, including medical care for injured airmen.) It has been estimated that bird ingestion around the world causes about one-third of total aircraft damage.

But it's only after the major reported accidents that the issue resurfaces, albeit temporarily. In the public consciousness, at least, bird strikes are an inevitable disaster. Yet there is an answer. It comes in the form of modern technology: more precise radar and monitoring networks providing early warning to planes can avoid birds.

Mention the project to Lockheed Martin, the company providing the radar equipment, or the IDF – which, in the case of bird strikes, is especially secretive on the subject – and they will both refer you to Yossi Leshem.

Leshem, who headed the Society for the Protection of Nature in Israel from 1991 to 1995, has been leading a crusade that has reduced the annual cost of bird-strike damages by 88 percent in the last decade. Now, with the use of radar, weather stations and bird migration research, he wants to reduce bird strikes even further in an effort to prevent a replay of September's accident.

"I didn't even know about the severity of the bird-strike problem when I went to find a research topic for my doctorate," says Leshem, who was studying zoology at Tel Aviv University in 1982. He found out about it when he approached the IAF for assistance in tracking birds' migratory paths. "I got a big shock [on learning] that from 1972 to 1983 there were 15 severe bird-related accidents." The damage to each plane was at least \$500,000. The only thing the Air Force was doing, says Leshem, was removing the birds from the runways. "And so, I found a topic," he says.

"The army said to me, 'What can anyone do [shoot out bird strikes]?' So I proposed a research project for them."

Leshem would learn about the birds and figure out how to reduce bird strikes. With the Air Force's help, he tracked the birds – often into classified areas which he would have not had access to without IAF permission – using gliders, 1,400 hours of radar and drones. He set up a network of bird watchers around the country to count birds. His project documented when migratory birds arrive and leave; their altitudes, their routes, and how weather influences their flight patterns.

Most of the accidents, Leshem's team discovered, occurred during migration periods in the fall and spring. In

ping over (see box), some even stay in the water. In 1984, Leshem started applying his findings. He introduced the concept of "bird plow zones" (BPZ). These are densely packed with migrating birds, the location and altitude varying with the time of year. With Leshem's data, BPZs were clearly delineated. The solution to bird strikes was relatively straightforward: stop flying there. And the Air Force did.

That decision came none too soon, because the concentration of planes at the time was even denser than it was from 1972 to 1983, the period Leshem had researched. In 1982, the Sinai was returned to Egypt. The airspace over that vast desert had been the IAF's main training area. All of those exercises were then moved back across the border to the narrow strip of airspace over the state, which was teeming with birds. Conservation and breeding efforts around the world had also contributed to an increase in the world bird population.

Leshem, who has been associated with SPNI since 1968, has done reserve duty with the Air Force. He represents the interests of both, as evidenced by the slogan: "Take care, we share the air." Known here and abroad as "the bird man," he has written and presented papers around the world.

It is estimated that bird ingestion around the world causes about one-third of total aircraft damage.

and to the Europe Bird Strike Committee - which meets every two years and on whose board he serves - on the cost of bird strikes to the military and ways of preventing them. Now that Leshem has shown the IAF that bird strikes can be minimized, he is ready to take the next step. He plans to purchase three radar dishes powerful enough to detect birds throughout Israel's airspace. He is also working in conjunction with the US, which is giving him access to its world weather satellite stations. The US has installed such radar systems and is starting to use them to prevent bird strikes, a serious problem there as well.

The New York Times reported on the danger of bird strikes at New York's Kennedy Airport, which is near a garbage dump. There is an average of 2,200 bird strikes with civilian aircraft each year in the US, according to the Times. In the next 10 years, the daily noted, citing the report of an aviation-safety consultant, there is a 25 percent chance of a deadly collision between a bird and an airplane in US airspace.

Leshem will combine all his data - from US and Israeli radar and satellites - using a mainframe computer at the new International Center for Studying Bird Migration at Latrun, which will serve as a base for all Israeli bird studies. The result, he hopes, will be safer flying over Israel and throughout the Middle East.

Leshem's next plan - more like a dream, given the nature of relations between Israel and its neighbors - is to bring Jordan, Turkey and, later, Egypt into the picture. He has already made presentations in Jordan and Turkey. The situation facing the Turkish Air Force is the same that the IAF faced before Leshem came along. "The idea is to do it all over the Middle East, so that we can give each other advance warning," explains Leshem.

Like idealists working on such matters as joint Israel-Arab educational and social programs, Leshem believes that mutual interest in creating safer airspace could improve relations with neighboring states. "The new slogan is 'Migrating birds know no boundaries,'" Leshem says.

He hopes that his new project will prevent accidents like the 1995 crash of the F-15. (A follow-up report on the September crash has not been released.) The fatal accident occurred five days before the migration period was presumed to begin, and five days before IAF jets would have been kept out of that bird plow zone. Weather and other circumstances probably contributed to the birds' presence. Radar and other early warning systems might have prevented the collision.

But Leshem knows he cannot control nature. "We can only reduce bird strikes by 95 percent [annually]," he says. "Nothing is 100 percent certain."



Bird man Yossi Leshem has been hunting a solution to reduce the cost of bird strikes to the military.



A flock of pelicans share the skies with a research motorized glider.

FISHING FOR TROUBLE

Yossi Leshem found a way for the IAF and birds to share the air, but fish breeders were less receptive to his message of coexistence.

For fish breeders, the migratory flocks are a plague on their innocent. For the birds, the densely packed fishponds are like a flashing neon road sign that reads: "Food - Stop Here."

One pelican can eat up to 1,200 grams of fish per day. A flock of 2,000 will consume two tons. About 70,000 pelicans fly over Israel per season. That's a potential loss of 70 tons of fish, a hefty bite out of every fish breeder's income.

They propose the pelican problem," says Rami Rosenzweig, a member of Tzfat Zvi, the kibbutz near Beit She'an which sells about NIS 42 million annually. Rosenzweig is an economist and works at the kibbutz fishponds. The solution has been a joint patent by Beit She'an-area fish breeders using noisemakers and other devices to scare the birds away.

But Tzfat Zvi has a more severe problem with cormorants, Rosenzweig says. They eat less than pelicans had (18,000 kg. of fish per year), but they are much faster and are not frightened by the patrols. In addition, the Nature Reserves Authority allows a limited number to be hunted each year. Combating them requires more severe measures than noisemakers: explosives. These have significantly reduced the number of cormorants by Tzfat Zvi's fishponds, according to Rosenzweig.

To combat both types of birds is costly. Each explosive charge costs NIS 25 and thousands are used each year. The pelican patrol costs some NIS 300,000 annually. Moreover, it is only a partial solution: the hungry birds

go elsewhere, increasing the problem for other fish breeders.

Enter Yossi Leshem. His proposal for the fishermen is similar to that he offered the Air Force: find a solution in which both can share the environment. Leshem suggests creating special lakes where fish breeders can dump refuse (scraps and live fish feed). The birds would then be able to feed up at designated locations.

"Leshem's idea is a very bad one," says Rosenzweig. "This thing that he calls 'refuse' - someone still has to make it and feed it and invest the money."

But Leshem says the breeders are short-sighted and claims it would be cheaper than their current tactics, which nationwide cost millions of shekels per year. This project, like that implemented by the IAF, would take six to seven years to produce rewards.

The breeders "don't want to invest any money unless they see immediate profits," says Leshem.

Furthermore, he says, the new fishponds would also be profitable in another arena: tourism. The SPNI, in coordination with kibbutzim of the north, is trying to attract some of the world's 13 million birdwatchers. When the tens of thousands of birds flock to the ponds, tens of thousands of tourists will flock to see the birds.

And this is what Rosenzweig's main fear seems to be. "With Leshem's plan, all the birds of the world will come here to stay," he says. "Since the beginning of time, birds have flown from Europe to Africa. In the last 30 to 40 years, we [in the North] are here with our fish," Rosenzweig says. "Let [the birds] go somewhere else."

Given the fact that Leshem has given up his fight against the fishermen, the birds will indeed have to find fish in another sea.

-A.K.

SOCIETY FOR THE PROTECTION OF NATURE IN ISRAEL

OFFER BUKAT

invited to attend.

Netanyahu will deliver a speech in which he is expected to refer to murdered Prime Minister Yitzhak Rabin. People close to Netanyahu say, however, that the prime minister does not intend to apologize for his part in the incident that preceded Rabin's assassination, as the left has asked.

A heavy cloud of suspicion and distrust between the prime minister and his cabinet, and between the ministers and Likud activists, hangs over the convention. Saturday night, senior Likud officials were apprehensive about what awaits them at the convention, including delegates' intentions to pass a proposal canceling internal party primaries and to choose a candidate from amongst themselves to the post of convention chairman. "If, by (Sunday), no compromise is found to appease the angry delegates, Netanyahu won't be able to prevent a cancellation of the primaries. This could lead to a factionalization of the Likud," a party leader said Saturday.

In an attempt to ease some of the tension in their party, Netanyahu and Likud secretary-general chairman, Health Minister Yehoshua Matza, decided Friday to convene another convention in February 1998. They promised that the changes in the Likud constitution such as the cancellation of the primaries and other proposals would be discussed at that time.

The announcement of a second convention did not satisfy Likud members who said they would not reconsider their intention to pass the proposal so that the power to decide the composition of the Likud list for the Knesset will return to the hands of the 200,000 party members. "Who knows, three months from now, the government could have already fallen," one delegate said.

Likud leaders held intensive last-minute contacts over the weekend to head off a showdown. Another bone of contention is the selection of the convention chairman. Netanyahu and his ministers would like the convention to select Matza, but a large group of activists prefer Yisrael Katz, a member of the Likud Central Committee. Feelings in the Likud are that Katz has a good chance of winning the highly influential position because he is supported by opponents of Netanyahu, supporters of canceling the primaries and opponents to Matza.



Hundreds of thousands gathered in Rabin Square in Tel Aviv Saturday night to mark the second anniversary of the assassination of Yitzhak Rabin and reaffirm their support for the peace process.

U.S. waits for UN to meet

By Shlomo Shamir
and Guy Bechor

Jerusalem Correspondents

The United Nations Security Council will convene an emergency session on Monday to discuss measures against Iraq following the failure of a diplomatic delegation to convince President Saddam Hussein to reconsider his expulsion of American arms inspectors. Iraq blocked American members of UN arms inspection teams for the sixth straight day on Saturday and a UN envoy said the standoff could lead to a military confrontation.

"The inspection team, which consists of two groups, halted its work after the relevant Iraqi authorities in two sites told them the

Americans were not allowed to take part," the Iraqi news agency INA quoted a source at the Iraqi Monitoring Directorate as saying.

Iraq on Saturday denied remarks by chief UN weapons inspector Richard Butler that Baghdad still possessed weapons of mass destruction. "There are no weapons of mass destruction in Iraq. There are no raw materials for their manufacture or production," INA quoted Major-General Hossam Mohammed Ameen as saying. Ameen heads Iraq's National Monitoring Directorate, the Baghdad government's agency for liaison with UN weapons inspectors.

Iraq has demanded that the UN weapons inspection teams be better "balanced" to include members

from all five countries on the Security Council (United States, France, Russia and China) and the current inspectors are American and European, although Russian missile experts have been in Iraq.

Iraq also appears to be asking surveillance planes be provided by any country other than the United States. The demands are contained in a letter sent by Iraq to UN Secretary-General Kofi Annan through a group of three UN envoys who arrived in Baghdad earlier in the week.

U.S. officials have warned that Iraq could be considered a threat to regional security if it carried out its threat to allow a U.S. surveillance plane to fly over the UN. The next flight is expected on Monday.

U.S. President Bill Clinton

Seagull threat to aircraft

By Zafir Rinat

Jerusalem Correspondent

Birds flocking to the Hirya waste dump in Tel Aviv could pose a major hazard to civil aircraft flying to and from Ben-Gurion airport, according to experts.

"There could be an air disaster this winter at Hirya that will make the Yasser helicopter accident (in which 73 soldiers died last February) pale by comparison," warned Yossi Leshem, special adviser to the Israel Airports Authority.

"If I were in the government, I would not sleep at night because of the danger," said Leshem, who has made a careful study of the problem.

Leshem's warning follows the arrival of the first flocks of seagulls from Europe and his fear that Hirya will not be closed within

the next few months, despite a government decision to do so. He said that the threat of birds to planes passing over Ben-Gurion airport needed to be taken even more seriously than in the past, given mounting evidence that birds can cause lethal damage to large four-engined planes as well as to smaller single or two-engined aircraft.

During the coming month, tens of thousands of seagulls are expected to flock to the area. They usually spend the night sleeping over the sea, flying by day to Hirya for food. Leshem said they sometimes flew at around three thousand feet, the same height as planes taking off and landing at Ben-Gurion. They also posed a threat as they cut across aviation lanes when they fly from Hirya to the waste dump at Modi'in.

Swiss judge Israeli ve Onassis

By Reuven Shapira
and Itim

A Swiss investigating judge rejected the version offered by police regarding Israeli involvement in planning the kidnapping of his heiress Athena Roussel.

Judge Jacques Delieuve, Geneva said he was astonished the Israeli police had provided a version of the facts without having obtained the entire file and material related to the matter.

The Israeli police say that the kidnapping story is a ploy by the heiress, who is engaged in a power struggle with the Greek managers of the Cypriot fund and Athena's father, T. Roussel. Their investigation

TEL AVIV UNIVERSITY



אוניברסיטת תל-אביב

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DEPARTMENT OF ZOOLOGY

הפקולטה למדעי החיים ע"ש ג'ורג' ס. וייס
המחלקה לזואולוגיה

9/11/97

HA'ARETZ

ENGLISH VERSION

APPENDIX 24

FAAviationnews, Nov./Dec. 1996:

Watch out for Rudolph! He may be trespassing on your airport



WATCH OUT FOR RUDOLPH!

by Sandy Wright

He may be trespassing on your airport

While deer/car collisions are common in the United States, many people are unaware that a number of deer/car strikes also take place. Since 1983 there have been 245 deer-related accidents reported, most of which resulted in serious damage to the aircraft. The actual number of accidents is probably much higher than this because many accidents are not reported. The data for this article was taken from two sources, the FAA Bird Strike Database and the National Transportation Safety Board (NTSB) Aviation Accident Database. The first relies on voluntary reporting of strikes by pilots and other aviation personnel; the second is information collected during investigations of accidents or incidents involving civil aircraft by the NTSB.

We know that many strikes with wildlife are not reported for various

reasons and estimate that 80% of these strikes may be unreported. Until the FAA Bird Strike Reporting Form 5200-7 was revised to include other wildlife, only bird strikes were reported, leaving us with an incomplete picture for deer strikes in the years before 1990.

Deer and other wild ungulates (hoofed mammals) inhabit all 50 states. Species include the white-tailed deer, mule deer, moose, and elk. The white-tailed deer, which is primarily an eastern species, has been the most commonly struck ungulate. An adult white-tailed deer weighs anywhere from 100 pounds to a record 511 pounds, with an average weight of around 125 pounds. Deer run at speeds up to 36 mph. Although deer prefer to crawl under fences, if disturbed, they will easily jump a seven-foot fence from a standstill or an eight-

foot fence with a running start.

Deer often travel in family groups of does and fawns. Males generally stay to themselves and only associate with females during the fall breeding season, also known as the rut. In much of North America the rut peaks in November. In southern states, which have a longer growing season, deer breed over a longer period of time.

DEER ARE INCREASING

There has been a dramatic increase in the deer population in the United States in recent years. At the turn of the century, deer had almost been hunted to extinction with only about 100,000 remaining, but they now number about 24 million.

Airports often are situated in outlying areas and are frequently surrounded by good deer habitat. Land-

ing fields provide prime locations for grazing because they are planted with grasses and other plants that attract deer. Deer in and around airports, should be a concern for pilots and airport managers because 83% of aircraft-mammal strikes are caused by deer.

FEMALES ON THEIR MIND

The worst month for deer-related incidents is November when the deer are on the move because of the rutting season. Young males are being chased off by adult bucks who are also busy courting does. These distractions are believed to be the reason that one-fourth of all deer accidents occur at this time.

WORST TIME TO FLY

Deer are most active in the twilight hours and at night when they feed. That is not to say that you won't see deer during the day, just that they are usually resting at this time. As you might guess, deer strikes with aircraft occur most often at dusk (47 strikes per hour) and at night (11 strikes per hour) when deer are most difficult to see. For example, one unfortunate pilot noticed a vague shape off the right side of the aircraft during take-off

on a dark night. He continued down the runway until his Piper PA-32R collided with an 180-pound deer.

Another pilot reported that a deer ran in front of his Cessna 172 during the flare for a night landing. The prop hit and killed the deer and the nose gear and bottom of the engine compartment were damaged. After the collision, the pilot smelled fuel fumes. When the front of the plane started sliding on the runway, a fire developed which destroyed the aircraft.

It was dusk when a Cessna 421 struck two deer. Although the pilot was not injured, the plane received substantial damage. The landing gear strut collapsed causing both props to hit the runway. The Cessna came to a stop on its main landing gear and the bottom of the fuselage just aft of the nose. The airport was closed for two and a half hours to clear the runway.

ACCIDENTS WHILE AVOIDING DEER

Some accidents were caused, not by actually hitting the deer, but by the pilot trying to avoid deer on the runway. These accidents occurred most often during the day (47%) when the pilot was able to see the deer but still resulted in 89% of the aircraft involved sustaining some degree of damage.

Extent of Damage	Damage caused by striking deer		Damage caused by avoiding deer	
	No. of incidents	% of incidents	No. of incidents	% of incidents
Destroyed	4	2	2	6
Substantial	83	40	29	81
Minor	74	35	1	3
Unknown damage	9	4	1	3
None	32	15	3	8
Unknown	7	3	0	0
TOTAL	209		36	

Table 1. Type of damage to aircraft

Year*	No. of reported strikes	% of strikes
1983	4	2
1984	3	-
1985	3	-
1986	8	4
1987	4	2
1988	2	1
1989	0	0
1990	10	5
1991	21	10
1992	30	14
1993	28	14
1994	52	25
1995	32	15
1996**	12	6
TOTAL	209	

*Deer strikes before 1990 were not reported to FAA on Form 5200-7

**1996 includes only January through August.

Table 2. Number of aircraft collisions with deer per year

One such incident occurred in Georgia when a pilot reported that he was landing the airplane in a strong left crosswind. As the airplane touched down, a deer darted across the runway. The pilot swerved abruptly to avoid the deer and was unable to recover directional control. The left wing dragged the ground and the plane nosed over when it rolled into a shallow, wide ditch. Luckily, there were no injuries, but the plane was damaged substantially.

Another pilot, in his attempt to avoid a collision, caused the airplane to veer off the right side of the runway into a stand of trees. He probably would have had a better chance with the deer—at least it might have moved!

PHASE OF FLIGHT

Most strikes happen during landing roll (57%) followed by take-off (30%). Only 9% occur on climb and approach combined. Somewhere between 53% and 79% of all deer encounters have



an effect on the flight, from aborted take-off to engines shut down to precautionary landings.

Although only 1% of strikes occur during taxiing, they can be just as serious as other strikes at higher speeds. In December 1994, the pilot of a Cessna 172 lost directional control of his aircraft while taxiing when seven deer crossed in front of the plane. He hit four deer and then hit trees on the

west side of the taxi way. The plane was totaled.

DEER TAKE THEIR TOLL

The aircraft was damaged in 81% of all reported deer strikes, and in half of those strikes the damage was substantial. Reports rarely showed the cost of deer-related damage: only 12% of the reports indicating damage provided estimates of the cost of repairs and time out of service. Based on the numbers from the strike reports providing damage estimates, the average deer strike cost was \$96,800. (Note that this amount does not include accidents from avoiding deer). If we multiply this by the 170 reported damaging strikes, we can estimate that the total cost since 1982 would be \$16,456,000. Remember that only about 20% of all strikes are reported so the real total is much higher. Also, none of the strikes in the NTSB database (30% of the total), which were all substantial, had figures for damage.

The most expensive strike reported was to a Hawker-Siddeley worth \$1.4 million. The 100 mph-impact tore the engine loose.

THE INVISIBLE DEER

Sometimes pilots might not see the deer or realize one was hit. For example, an instructor pilot was demonstrating night landings to his student

when the aircraft veered to the right on touchdown. The instructor thought that the student was on the right rudder but failed to override him by applying left rudder. The real story wasn't discovered until the next morning. The aircraft had collided with a deer on touchdown and had dragged the deer some distance with the right main gear. This strike, not the student pilot, was what caused the aircraft to veer to the right.

DEER CENSUS

As mentioned earlier, it is estimated that there are over 24 million white-tailed deer in the United States. Deer populations vary from state to state as do the amount of deer-related incidents. It seems that eastern states have the greatest problem. The state having the most deer strikes reported is Pennsylvania (13%) followed closely by West Virginia (11%) and Michigan (9%). Thirty-nine states have reported deer strikes or deer-related accidents with aircraft.

NO FATALITIES - YET

Reported injuries from deer strikes have been few. This may be because 1 is not one of the items specifically asked for on the FAA forms. The only serious injury reported was in 1992 in Minnesota. The pilot of a Piper Cherokee hit a deer on rotation. When he attempted to turn back to the airport, the plane crashed into some trees 1/4 mile south of the runway. The pilot was seriously injured, and the aircraft was destroyed.

WHAT IS BEING DONE?

What can be done to prevent future deer strikes? Airport managers can request help from professional wildlife biologists who will then assess each airport's particular situation and provide recommendations to solve their problem. In many cases, habitat modification to remove nearby wooded or brushy areas is all that is necessary.

At the present time, chasing deer

State	No. of reported strikes	% of total strikes
PA	26	12
WV	23	11
NY	17	8
MI	18	9
NJ	16	8
WI	9	3
VA	8	4
CT	7	3
MD	7	3
OH	6	3

Table 3. Top 10 states for deer strikes

Month	No. of reported strikes	% of strikes
JAN	9	4
FEB	6	3
MAR	14	7
APR	12	6
MAY	10	5
JUNE	13	6
JULY	17	8
AUG	11	5
SEPT	12	6
OCT	36	17
NOV	51	25
DEC	18	9
TOTAL	209	

Table 4. Number of aircraft collisions with deer per month

Time of Day	No. of reported strikes	% of strikes
Dawn	3	1
Day	34	16
Dusk	35	17
Night	128	61
Not reported	9	4
TOTAL	209	

Table 5. Number of aircraft collisions with deer by time of day





off runways with a vehicle before take-offs and landings is the most widely used method. Noise makers are only effective for short periods of time, because deer grow accustomed to them. Harassment and pyrotechnics are used at some airports and have proven to be only partially successful. This is not practical 24 hours a day and not all deer respond to these deterrents.

Fencing has been an effective, but expensive, management tool for excluding deer. Fences must either be between eight and 10 feet tall or, if shorter, electrified. All fences must be maintained so that deer cannot crawl under them. Cattle guards (bars of narrowly spaced steel rod) must be in place at entrances. Smaller airports cannot afford this type of protection. FAA regulations do not require airports to have a fence but only require them to take precautions against entry of large domestic animals onto air operations areas.

Supplemental feeding away from runways or the use of scent repellents

can move deer away from the runways. Feeding only works when other food sources are low or unavailable. However, feeding the deer encourages them to stay in the vicinity.

Repellents are needed in large amounts, are expensive and time consuming to apply, and require continuous reapplication. Generally they are not practical.

Deer can be captured and relocated. However, this is labor intensive, can be dangerous, and stresses the deer causing a low survival rate. Deer are extremely territorial and don't do well when placed into new surroundings. Transporting them is just too traumatic. It is also difficult to find new locations that are not already saturated with deer. Furthermore, it is unlikely that all deer can be removed this way.

In recent years several U.S. airports have had to resort to having hunters shoot deer on airports because of the number of deer on the airport property. The number one issue is to enhance airport safety.

AVOIDING DEER STRIKES

How can you avoid a damaging wildlife strike? First of all, know which airports you use are likely to have deer. Check with the appropriate FAA Airport/Facility Directory (AFD) for warnings about deer populations. The Aircraft Owners and Pilots Association's (AOPA) *Aviation USA* also has specific warnings for deer at airports. Second, try to fly during daylight hours as most strikes occur at night and at twilight, especially during autumn. Finally, remember to keep control of your aircraft at all times. Many accidents were caused by pilots being distracted or trying to avoid deer on runways.

REPORT YOUR STRIKES

If you are involved in a deer or other wildlife strike accident, be sure to fill out the FAA Form 5200-7 which can be obtained from local FAA offices, airports, and the AIM, Appendix I. With the help of people reporting all

wildlife strikes, we will eventually have a strong database which can be used to assist wildlife biologists and airport managers to prevent, or at least greatly reduce, future strikes.

Author's Note: I would like to thank the following people for their assistance in providing support for this article: Ed

Cleary, FAA Office of Airport Safety & Standards; Satish Agrawal and Tom Hupf, FAA Technical Center; Richard Dolbeer and Andy Montoney, USDA/APHIS/ADC; and Gene Wright, Ohio Department of Natural Resources.

Ms. Sandra Wright is employed by the U.S. Dept. of Agriculture, National Wildlife Research Center in Sandusky, OH. She manages the FAA's Wildlife Strike Database. The database has had over 15,000 reported wildlife strikes to aircraft since 1989 and is growing by about 2,200 strikes a year. Wildlife includes birds, mammals and reptiles—in fact, any animal involved in an aircraft strike. The tables included in this article are based on information from the FAA Wildlife Strike Database and the NTSB Aviation Accident Database for January 1983 to August 1996.



Phase of flight	No. of reported strikes	% of strikes
Takeoff	63	30
Climb	10	6
Approach	9	4
Landing roll	119	57
Taxi	3	1
Not reported	5	2
TOTAL	209	

Table 6. Number of aircraft collisions with deer by phase of flight

Effect on Flight	No. of reported strikes	% of strikes
Not reported	54	26
Other	63	30
None	44	21
Aborted takeoff	25	12
Precautionary landing	21	10
Engine shut down	2	1
TOTAL	209	

Table 7. Number of aircraft collisions with deer as they affect flight

APPENDIX 25

Morning Smile

YOUR MORNING SMILE

An Englishman, a Canadian and an American were captured by terrorists.

The terrorist leader said: "Before we shoot you, you will be allowed last words. Please let me know what you wish to talk about."

The Englishman replied: "I wish to speak of loyalty and service to the crown."

The Canadian replied: "Since you are involved in a question of national purpose, national identity and secession, I wish to talk about the history of constitutional process in Canada, special status, distinct society and uniqueness within diversity."

The American replied: "Just shoot me before the Canadian starts talking."

APPENDIX 26

Winnipeg Airports Authority: Bird Control Advisory Committee Update

WIA

Bird Control Advisory Committee

Membership

WAA	(chair)
BFI	(operator, new landfill site)
City of Winnipeg	(operator, old landfill sites)
Correctional Services	(Stony Mt.)
Transport Canada	
Darryl Watkins	
ACPA	
Manitoba Environment	
Manitoba Natural Resources	
Nav Canada	(Control Tower)
Richard Sowden	

WIA

Bird Control Advisory Committee

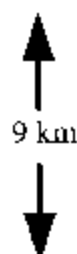
-last meeting held at end of Sept. 1997

1. Members were up dated on the closure of the Summit Road landfill site by Tony Kuluk of the City of Winnipeg (it will stop accepting refuse beginning February 1998). This site is located within 10km to NW of WIA.
2. Next was the briefing by Chuck McCandless of the opening and operation of the composting facility at the Stony Mountain Institute (which is 15km north of WIA). They cannot use conventional methods for scaring the gulls that are attracted to the site.
3. Stan Kruse from BFI briefed everyone on the successful results of the Bird Control Program that was implemented at the BFI landfill site located 9km north of the WIA.
4. Murray Gillespie (MB Natural Resources) gave presentation on migration of Canada Geese and Snow Geese in relation to Oak Hammock Marsh (located approximately 25km NE of WIA). Oak Hammock Marsh is a staging area for Geese on their migratory route and presents problems specifically for WIA.



Stony
Mt.
(Compost Facility)

BFI
(New Landfill Site)



Summit Rd. Site
(Old Landfill Site)
(to be closed)

WIA

Brady Rd. Site
(Old Landfill Site)

APPENDIX 27

Assessment of Browning-Ferris Industries (BFI) Gull Control Program at Rosser Integrated Waste Management Facility

**Assessment of Browning-
Ferris Industries (BFI)
Gull Control Program at The
Rosser Integrated Waste
Management Facility**

November 13, 1997

Assessment of Browning-Ferris Industries (BFI) Gull
Control Program at the Rosser Integrated Waste
Management Facility

Browning-Ferris Industries

97-4745

Submitted by

**Dillon Consulting
Limited**

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1.0 INTRODUCTION

Dillon Consulting Limited (Dillon) conducted a fall 1997 study of gull numbers to assess the effectiveness of the Gull Control Program (GCP) at the BFI Waste Management Facility in Rosser, Manitoba. The waste management facility is found within the flight path for the Winnipeg International Airport, and it was recommended that BFI implement a Gull Control program to minimize the potential for gull numbers to increase within the region (L.G.L., 1996).

This study was designed to assess the effectiveness of the existing GCP at the landfill, in terms of its ability to minimize the number of gulls found within the Waste Management Facility. It is BFI's policy to minimize impacts of birds on landfill operations and on surrounding properties by appropriate control techniques.

2.0 OBJECTIVES

The objectives of this study were as follows:

- Gather data on the relative abundance of gulls on the site and in the area, and estimate species composition.
- Estimate the ratio of adults to juveniles found at the landfill site, in order to subjectively determine the number of breeding gulls in the area. This information, in conjunction with data on the numbers and species of gulls in the area, can be used to document changes associated with fall migration.
- Conduct interviews with BFI personnel to determine how they implement the GCP.
- Document all bird species found at the site.

3.0 METHODOLOGY

Background data on the relative abundance of gulls in the area was obtained through a review of L.G.L. reports (1995 and 1996), and conversations with Transport Canada (Ray Rokosh, Bruce Applin) and the Rockwood Waste Management Facility (Chuck McCandless).

Ten one-hour field visits were conducted between October 10 and October 16, 1997. During each field visit the observer would start in the Southwest corner of the active landfill cell and walk along the perimeter of the property for a one hour period. The manager of the site was interviewed and the records of pyrotechnics used were reviewed to assess the implementation of the current GCP.

4.0 HISTORICAL CONTEXT

Three species of gulls are common to the Winnipeg area: the ring-billed gull, herring gull, and Franklin's gull. In 1995 and 1996, before the opening of the Rosser Facility, the number of gulls (and other landfill related birds) was censused at the Summit Road and Brady Road landfills in the City of Winnipeg (L.G.L. 1995 & 1996).

Gull numbers were counted as they arrived at each landfill site in the morning from their night roosts. The number of birds observed during a one hour observation period ranged from 313 to 4,695 during the spring of 1995 (April 29 to June 1).

At the Summit Road landfill morning arrivals averaged 783 gulls/hour although numbers of gulls declined throughout the spring. Gulls arrived from the ENE quadrant, with most gulls arriving between 60 and 70 minutes after sunrise (L.G.L. 1996). Fall observations at the Summit Road Landfill indicated that 286 to 9,010 birds (herring gulls and ringed-billed gulls) were observed during a three hour period. The L.G.L. (1996) study found that gull numbers remained constant from September to October, and declined in mid-November. Sharp declines in the number of Franklin's gulls were observed in early autumn. Ring-billed and herring gulls were the only gull species observed during the late autumn period. Flight paths in Autumn were between Brady Road Landfill and the Fort Whyte Centre and between the Summit Road Landfill and the Wilkes Sewage lagoon (Figure 1).

The L.G.L. (1996) survey conducted from September 8 to November 14, involved observing gull use and other birds during roadside surveys surrounding the Summit Road Landfill and the BFI site before its development. It was found that many gulls were observed in agricultural fields, especially those being worked by tractors, and a major gull attraction in the area was small swine operation approximately 2 km west of the BFI site.

The L.G.L. (1996) report concluded that the preliminary analysis of towering gulls and aircraft flight patterns suggests that gulls circling over the proposed landfill at the BFI Rosser site would create only a minor hazard to the safety of aircraft using the WIA. In the report it was estimated that hazards to aircraft involving non-gull species would not likely be created by the Rosser Landfill. It was also recommended that a Bird control program be instituted at the proposed landfill at the BFI Rosser Site.

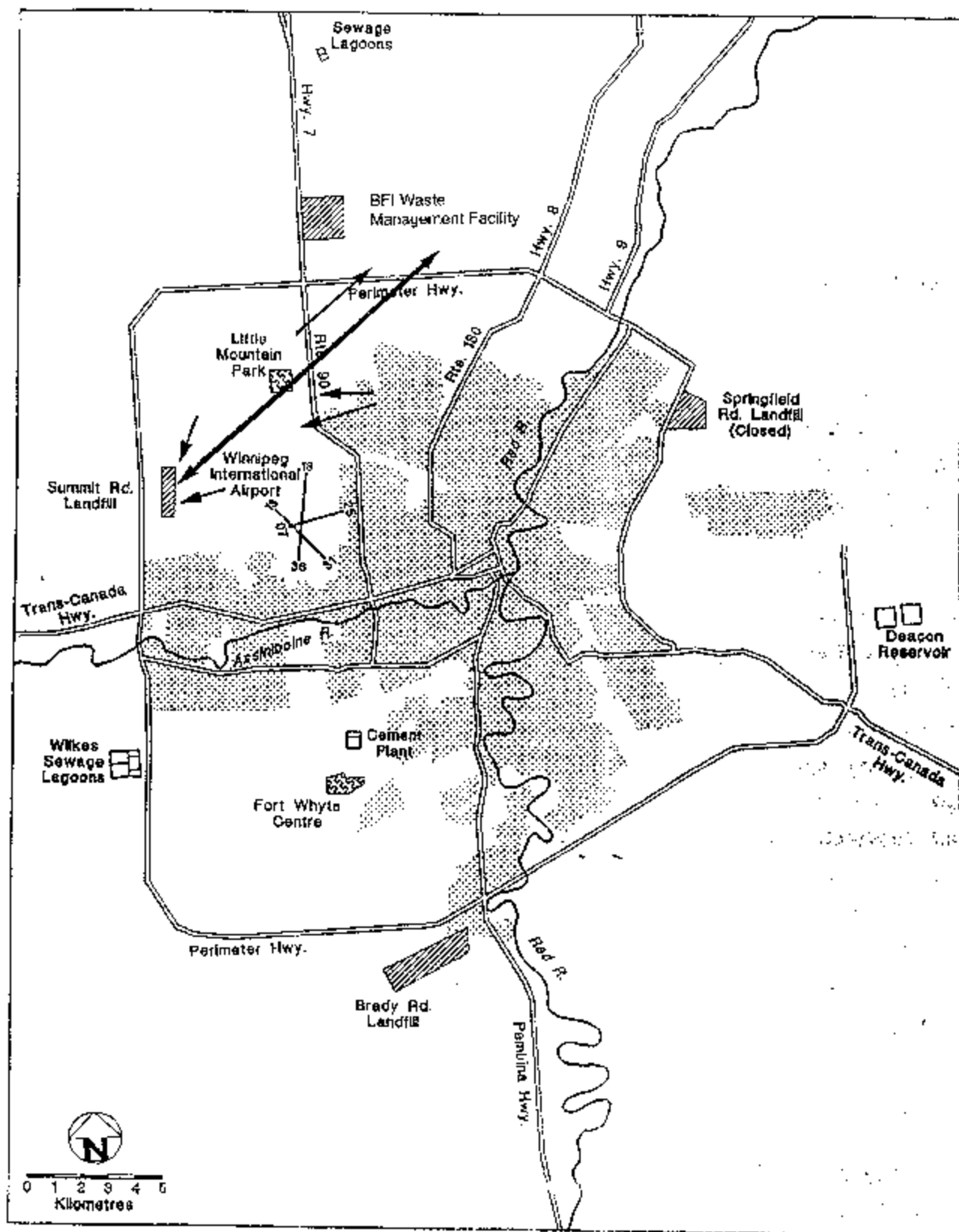


Figure 1: Approximate Flight Paths of Gulls in the
Winnipeg Area
Source: L.G.L. Report 1996

Project Number

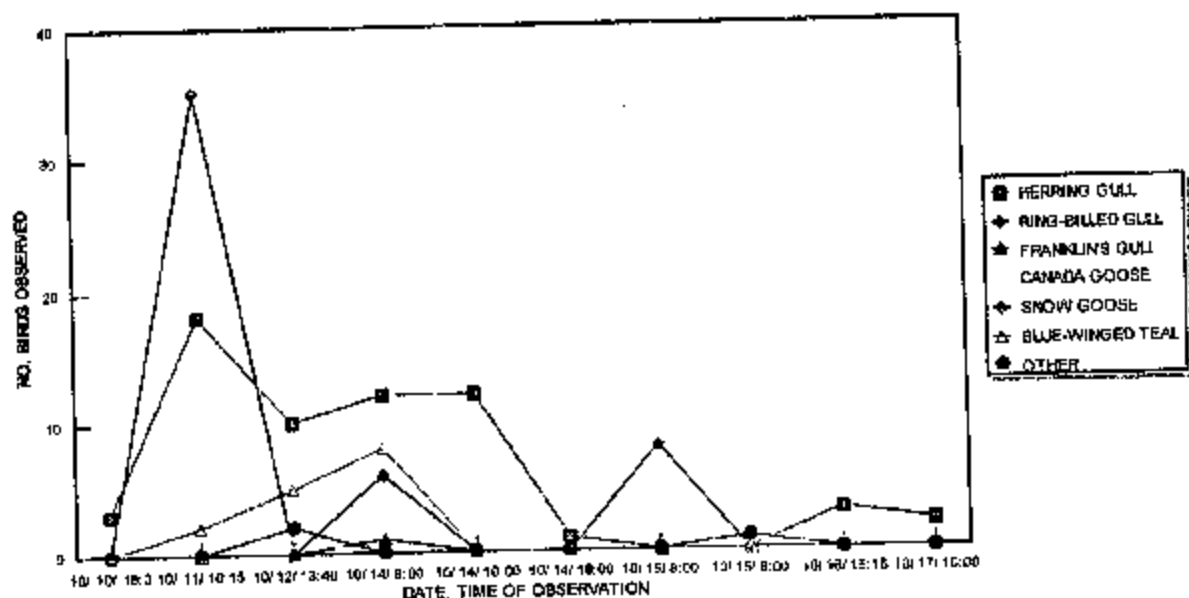
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5.0 FALL 1997 SURVEY RESULTS

Ten 1-hour observation periods were conducted from October 10 to October 16, 1997 during the fall migration period. Observations points were primarily located in the Northwest corner of the active landfill cell (Plate 1). During each visit, the observer began the observation session in the southern corner of the active landfill cell and then walked slowly north around the cell block to cover the entire landfill area. Incidental observations of gulls around the remaining property were noted wherever possible. In order to obtain a representative sample of gulls at the waste management facility observation sessions were conducted at various times throughout the day (sunrise, mid-morning, mid-afternoon, late afternoon, and sunset) and at times where the waste management facility was in operation or closed.

A total of 69 gulls were observed during the observation periods (6.9 gulls per observation hour). The majority of gulls observed were herring-gulls (90 percent), Ring-billed gulls (9 percent) and Franklin's gulls (1 percent). Peak gull numbers (18 on October 11; 19 on October 14) occurred during mid-morning observations. Only three (four percent) of the gulls observed were juveniles or immature gulls.

Field observations appear to be consistent with the 1996 L.G.L. report, which indicates that Franklin's gull numbers decline sharply during mid- autumn. Figure 2 provides a summary of field observations, and a complete listing of observation is be found in Appendix 1.



*Assessment of Browning-Ferris Industries (BFI) Gull Control Program
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All gulls observed during the study were flying at an altitude of approximately 60 metres (200 feet), and no observations of gulls landing or feeding on the cells were made. This included post-operational hours, when no gull control was conducted. The majority of gulls observed were flying over the landfill site from the northeast towards the northwest. As the Figure 2 indicates, Canada geese and Snow geese were the most numerous birds found at the site, although all observations of these birds occurred either overhead or adjacent to the active landfill cell. Several observations of blue-winged teals were noted during the observation sessions. These birds were observed in the drainage ditch that runs alongside the north side of the landfill cell. Other species observed at the site included house sparrows, and cedar waxwings.

For comparative purposes, the Rockwood waste management facility was observed. The facility is located approximately 10 km north of the BFI waste management facility. Approximately 100 herring gulls and ring-billed gulls were found at the site during the mid-afternoon observation period (October 17, 1997) (Plate 2). Gulls were observed to be loafing, roosting and feeding on the compost piles throughout the waste management facility. Monthly reports completed at the Rockwood facility indicate that gull numbers can range from 3800 to 1065 (ranging from 314 gulls to 62 gulls/per observation period) throughout the summer season (Rockwood Monthly Summary Report- August, September and October 1997). The most abundant gulls are Franklins gulls, then ring-billed, herring gulls and Bonaparte's gulls. Approximately 40 percent of gulls observed at the facility were juveniles, and the majority of birds observed were flying at or below 60 m (200 ft) (Rockwood Monthly Summary Report- August, September and October 1997).

Discussions with Transport Canada personnel (Bruce Applin, pers. comm.) indicates that airport personnel have not noticed an increase in gull numbers at the Winnipeg International Airport subsequent to the opening of the waste management facility in Rosser. Airport personnel are primarily concerned about the potential for interactions between arriving air crafts and gulls flying at altitudes greater than 200 m (W. Dewit, Bird Control Advisory Committee Meeting, October 29, 1997).

*Assessment of Browning-Ferris Industries (BFI) Gull Control Program
at The Rosser Integrated Waste Management Facility*

Plate 1 Observation Area in Active Landfill Area - BFI Waste Management Facility, Rosser, MB

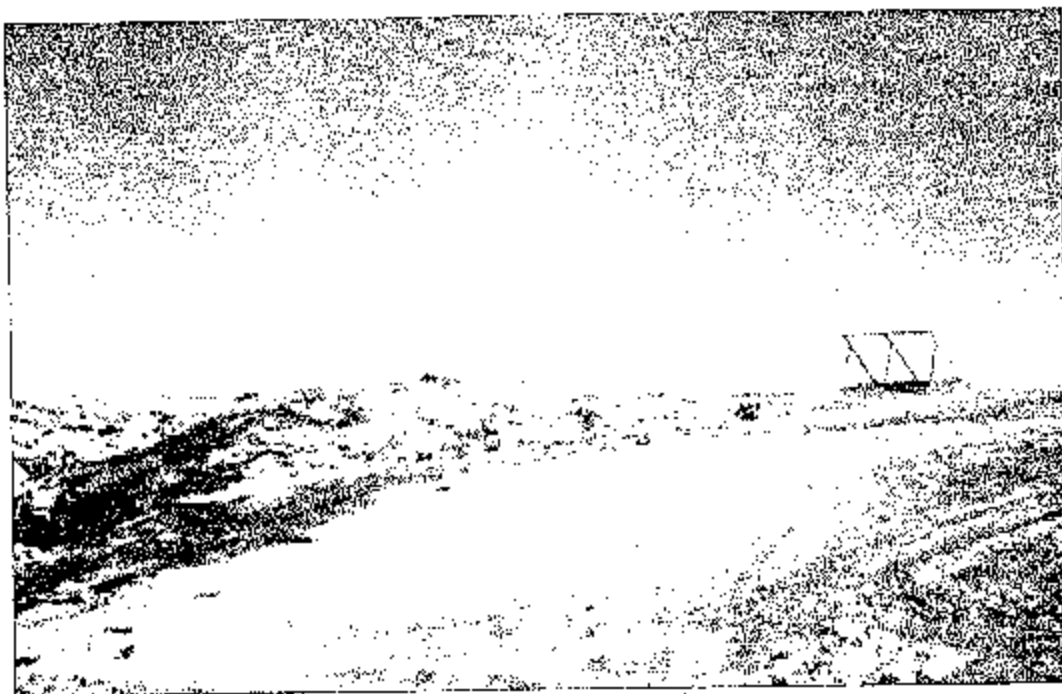


Plate 2 Gulls loafing, feeding at the Rockwood Waste Management Facility



6.0 ASSESSMENT OF GULL CONTROL PROGRAM (GCP)

The assessment of the GCP is based on gull observations and a questionnaire completed by the Operations Manager (Joe Gamby) for the Integrated Waste Management Facility in Rosser. The critical objective of the BFI GCP is that *Gulls must never be allowed to feed or loaf on any part of the Landfill Property*. The L.G.L. (1996) report completed for the waste management facility recommended that the GCP should be implemented as soon as the facility became operational. In order to accomplish this objective the existing GCP at the waste management facility involves a combination of habitat management and pyrotechnics which are designed to prevent the gulls from using any part of the property. Habitat management techniques were outlined in Section 6.7 of BFI's Landfill Procedures Manual, and included management recommendations such as minimizing the amount of exposed bare soil so that gulls will not be attracted to potential loafing areas (L.G.L., 1996). If necessary, it was recommended that parallel lines be strung over the potential loafing areas that are created by active landfill. BFI's Landfill Procedures Manual states that the main element of control should be active deterrent mechanisms (such as pyrotechnics, distress calls, models of injured gulls, killing of small number of gulls) to reinforce other scare tactics.

Observations of the GCP indicated that the pyrotechnics (screamers and bangers) were effectively preventing the gulls from landing or feeding on the active cells. Pyrotechnics were only fired when the gulls were within range of the pyrotechnic device being used. All observations of pyrotechnic indicated that they were being deployed when gulls approached a 30 to 60 m (100 to 200 feet) range in altitude. Typically, screamers and bangers were fired only once or twice in quick succession and only once were three shots sent off consecutively. The order in which the screamers and bangers were shot was also alternated. Figure 3 displays the number of screamers and bangers used since April 1997. Figure 3 also illustrates the trends in the amount of pyrotechnics required: more pyrotechnics were used during the spring migration and then use tapers off during the summer and fall seasons.

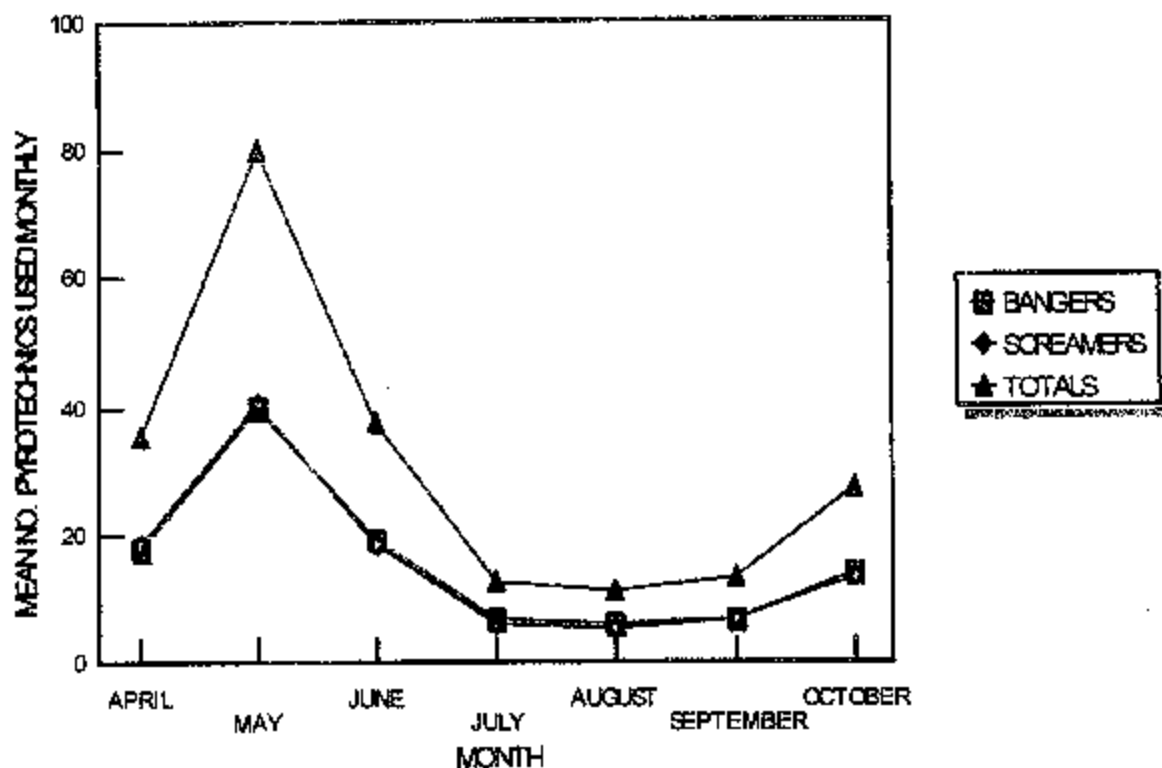
Four vehicles (compactor, rock truck and two dozers) were equipped with pyrotechnics, and all personnel operating these machines were trained in their use. In addition, the manager and the supervisor have access to a shot gun which was stored inside the office facility. The shot gun was used when it was deemed necessary to destroy a pest bird. Eleven gulls have been killed since the opening of the BFI facility in October, 1996 (Stan Kruse, pers comm.). The site manager indicated that the majority of these kills occurred after operation hours (weekdays, Sunday or Saturday afternoons), when machinery disturbances were not present..

When gulls were killed, the carcasses were placed on top of the active landfill site to discourage other birds from attempting to land or feed on the site. Personnel indicated that this was an effective means

*Assessment of Browning-Ferris Industries (BFI) Gull Control Program
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for deterring gulls. No distress calls or playback calls were used at the site, and at the present time it does not appear that these are necessary to control gulls.

Figure 3 Number of Pyrotechnics Used



7.0 CONCLUSIONS

The current GCP at the waste management facility appears to be meeting its objective of no gulls being permitted to feed or loaf on the site. Throughout the observation sessions no gulls were seen landing on the active cells. BFI personnel are employing the pyrotechnics available to them in a manner that is consistent with the approach outlined in Section 6.7 of the Landfill Procedures Manual. Gull numbers have not been observed to increase within the surrounding areas (particularly the Winnipeg International Airport, and the Rockwood Waste Management Facility)(Bruce Applin, Chuck McCandless, pers comm.).

An assessment of field observations of gull numbers at the facility during the fall of 1997 indicate that the site does not appear to have caused an increase in the number of gulls flying over, loafing or feeding on the site from the period prior to its establishment. Only four percent of all gulls observed were juveniles.

8.0 RECOMMENDATIONS

At the present time, it does not appear necessary to implement further habitat or pyrotechnic programs as there are fewer gulls at the BFI site when compared with other facilities in the area (Winnipeg International Airport, Rockwood waste management facility). However, if future monitoring results indicate that gull numbers are increasing, it may be necessary to expand the habitat management program and the active bird control program.

It is recommended that spring monitoring program be completed in order to satisfy the operating licence requirements for the facility. Future discussions with Manitoba Environment and BFI should determine ongoing bird control monitoring parameters required for the waste management facility. It must be noted that observations and conclusions drawn from this report concern the present operating conditions of the facility, and if the facility changes its operations, in the future, further investigations and monitoring is recommended.

Effective management plans for the BFI facility cannot be based solely on monitoring results at the site. Gull abundance is based on regional as well as site specific factors. Gull populations may be influenced by factors at other locations in their seasonal or daily migratory route. An effort was made during this study to gather data from other sites to place results at the facility in perspective. However, long-term monitoring and management should be based on a cooperative effort with other "stakeholder" groups. Information on natural /international populations status and trends should be gathered. Formal communications on the status of gulls in the Winnipeg area should be enhanced through regular meetings of the stakeholders such as the City of Winnipeg, Transport Canada, etc. Cooperative efforts

*Assessment of Browning-Ferris Industries (BFI) Gull Control Program
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should be made to divert gulls and other nuisance birds to "safe" locations that do not pose risks to aircraft operations. More information is required to develop a regional study that defines key habitat locations for feeding, loafing drinking and roosting for gulls and other nuisance birds.

9.0 REFERENCES

- L.G.L Environmental Research Associates, 1995. Initial evaluation of potential bird hazards to aircraft associated with a proposed landfill north of Winnipeg International Airport. L.G.L Report No. TA2086-2. 27 pp.
- L.G.L Environmental Research Associates, 1996. Evaluation of potential bird hazards to aircraft associated with a proposed Rosser landfill north of Winnipeg International Airport. L.G.L Report No. TA2086-3. 72 pp.
- Wildlife Control Procedures Manual, 1994. Environment and Support Services, Safety and Technical Services, Airports Group, Transport Canada.

APPENDIX 2

AUDIT RESULTS

Monitoring of Gull Control Program at Prairie Green IWMP Audit Checklist

Audit #1

Date: Oct 7/1997

Background Information

- 1) How long has the bird control program been in place? *Since the beginning of April 1997.*

Habitat Management

- 2) Adjacent Vegetation condition. *Some bare ground along side the active cell site and the developing cell site*
Are areas that are not active within the landfill revegetated immediately? *No they are attracting gulls and it has not been deemed necessary to date.*
Height of Vegetation in inactive areas. *Variable from 10 to 50 cm.*
- 4) Placement/Condition of low level-grids (as per sec 6.72 Control Methods?) *Not deemed necessary.*
- 5) Are stormwater/retention ponds or drainage ditches attracting gulls? *Field observations and anecdotal information by BFI personnel indicate that drainage ditches on the property are not attracting gulls, a few observations of blue-winged teal in the area was noted during field observations.*
If yes is further management required? *Not required at this time.*

Active Control

- 6) Number of screamers and bangers fired daily: *It varies from a low of 0 to 225 (total and bangers 1-112 and screamers 0-88) during peak season (early May).*
Is a daily inventory maintained? *More or less- a Bird control log book is maintained on site and employees are to total the number of screamers and bangers.*
- 7) Number of "cracker" shells fired daily. *Not used- BFI personnel indicates that screamers and bangers are more effective.*
- 8) Specifically, in what locations are pyrotechnics required *random- wherever required with active landfill cell area only.*
- 9) Are shell types rotated to avoid Gull habituation? *Bangers used more frequently than screamers, but the two are rotated.*
- 10) Are distress calls used? *No* How frequently? *NA*

- 11) Incidence of Lethal control reinforcement used monthly: *Monthly totals are not recorded- although the total number of birds killed since the opening of operations is 8-10. Records maintained? No*
- 12) Are carcasses mounted and used as gull models? *No carcasses are placed on top of the active cell are left there for a few days. If yes, how often are Gull mounts used? Not used. How often are Gull mounts Rotated? NA*

Control Personnel

- 13) Level of training received: *All personnel have been trained*
- 14) Number of gull control personnel on staff: *All personnel are trained:*
- 15) Hours of Gull Control operation: *Concurrent to landfill hours of operation*
- 16) Background experience of Gull Control personnel: *None required*
- 17) Number of Pyrotechnics used Daily: *Five to six pyrotechnic kits are available of which three to four are always located on compactor, rock truck, dozers (2).*
- 18) Time of Day pyrotechnics used: *All day.*
- 19) Seasonal Fluctuations noticed by staff: *Gulls numbers seem increase in spring (early May) and fall (early August).*
- 20) Areas commonly requiring active bird control management: *Throughout active cell area, and adjacent buffer zones*
- 21) Total Hours of Coverage: *Continuous*
- 22) Is coverage increase during Summer Hours ? *No, not required at this time.*

Equipment

- 23) Do Bird Controllers have fulltime access to suitable vehicle? *All personnel involved in Bird control program- all operating equipment is involved in GCP*
Is vehicle equipped with acoustic transmission systems? *No- no distress program in place*
- 24) Number of pyrotechnic pistols on hand: *5*
Number of 12-gauge shot guns on hand: *1- and is kept in the office- only the supervisor or manager may kill a gull)*
Quantity of screamers and bangers shells maintained: *a case of each (25 in each box- and 50 boxes in each case)*

25) Permit to harass to kill gulls available: *Yes Permit : See attached*

APPENDIX 1

SUMMARY OF OBSERVATIONS

OBSERVATION DATE	TIME	SKY	TEMP (DEGREES CELSIUS)	NO. BIRDS OBSERVED	ALTITUDE (M)*	JUVENILES	SCREAMERS	BANGERS
OCTOBER 10	18:00	OVERCAST	10	3 HERRING GULLS	> 60 m	1 HERRING GULL	0	0
OCTOBER 11	10:15	LIGHT RAIN	14	18 HERRING GULLS 35 CANADA GEESE 35 SNOW GEESE 2 BLUE-WINGED TEALS	> 60 m < 60 m > 60 m > 1 m		2	4
OCTOBER 12	13:40	OVERCAST	11	10 HERRING GULLS 2 AMERICAN CROWS 3 BLUE-WINGED TEALS 1 CANADA GEESE	2- > 60 m 8- < 60 m > 30 m > 1 m > 60 m		0	0
OCTOBER 14	09:00	PARTLY CLOUDY	3	12 HERRING GULLS 6 RING-BILLED GULL 1 FRANKLIN'S GULL	4- > 30 m 8- < 60 m > 50 m < 20 m		6	5
OCTOBER 14	10:00	PARTLY CLOUDY	3	12 HERRING GULLS	2- > 30 m 10- < 60 m	2 HERRING GULLS	2	2
OCTOBER 14	18:00	OVERCAST	5	1 HERRING GULL 6 CANADA GEESE 8 SNOW GEESE	< 30 m > 60 m > 80 m		0	0

OBSERVATION DATE	TIME	SKY	TEMP (DEGREES CELSIUS)	NO. BIRDS OBSERVED	ALTITUDE (m)*	JUVENILES	SCREAMERS	BANGERS
OCTOBER 15	09:00	SUNNY	4	1 HERRING GULL 1 CEDARWAX WING	> 30 m > 10 m		1	0
OCTOBER 16	15:15	SUNNY	14	3 HERRING GULLS 1 CANADA GOOSE	< 60 m < 60 m		0	0
OCTOBER 17	15:00	SUNNY	14	2 HERRING GULLS	< 60 m		2	1

* Estimated Altitude

APPENDIX 28

Wildlife Management at YVR & Environs - Report of a System Safety Review, July 23-24, 1997



Wildlife Management

at

YVR

&

Environs

Report of a System Safety Review,

July 23-24, 1997

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Executive Summary

Since the establishment of the Sea Island Conservation Area (SICA), annual safety reviews have been conducted in order to assess its risk to aviation at Vancouver International Airport. In 1996 the review was expanded to include wildlife present elsewhere on Sea Island and in the proposed Sturgeon Banks Wildlife Management Area (WMA). This year, the area under consideration also included Iona Beach Regional Park.

Vancouver International Airport Authority, LGL Environmental Research Associates, Canadian Wildlife Service, B.C. Ministry of Environment, and Wildlife Habitat Advisory Committee on Compensation personnel were interviewed and a number of documents were reviewed. The Safety Review Team (SRT) attempted to determine if there were significant changes to bird populations, wildlife behaviour, habitat values or wildlife control procedures during the past year. The 1996 safety review report included a number of observations and evaluated attendant risks in terms of probability and severity. This evaluation was broken into the following areas: SICA, Airport Property, Sturgeon Banks WMA and Iona Beach Regional Park. The risk to departing and arriving aircraft was assessed for a number of different species in each of these areas. The 1997 SRT concluded that there were no significant changes to the risk assessments contained in the 1996 SRT report. The SRT also reviewed wildlife habitat enhancements proposed for Iona Beach Regional Park.

The SRT concluded:

- The 1996 Safety Review contained a strong recommendation that action be taken to prevent Russian Snow Geese from wintering in portions of Sturgeon Bank WMA near the airport approach and departure paths. Active control measures have been taken against these birds within the airport boundaries but, to date, mitigation action has not been undertaken in the area west of the airport fence.

This hazard was originally identified in the 1995 report of The Blue Ribbon Panel on Wildlife and Aviation Safety. That report was accepted by Transport Canada, Vancouver International Airport, the Canadian Wildlife Service and several other parties. It contains a risk analysis and supporting information regarding the snow goose problem and was accepted and signed off at a high level by each participating party. In addition to senior Regional Management, the Acting Assistant Deputy Minister of Airports Group signed on behalf of Transport Canada.

In spite of this two year old report, the Airport Authority appears to feel that it must obtain a permit to undertake control action against the Snow geese. In response, CWS appears to be requiring additional detailed information, much of which was included in the Blue Ribbon Panel report. Transport Canada remains involved because, although they no longer operate the airport, they do own portions of the foreshore west of the airport boundary fence. At present, the situation appears deadlocked. In view of the potential severity of an aircraft accident that might be caused by these birds, the SRT wishes to express, in the strongest possible terms, its concern with the continuing lack of action on the part of Transport Canada, Vancouver International Airport and the Canadian Wildlife Service toward resolving this significant hazard.

- While the SICA Management Plan appears to provide adequate mitigation, some elements of the plan are not being performed. Strip mowing to encourage desirable bird species in old field portions of SICA has not taken place and signs intended to discourage humans from entering the area and disturbing the birds have not been erected.
- The existing wildlife control program on the airport property is being executed with great dedication and resolve. Modifications that are intended to increase the program's effectiveness are expected to be undertaken in the near future.

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- The Airport Authority is conducting tests of habitat management options that may lessen airport bird populations while reducing the requirement for active wildlife control. Experimental plots of reed canary grass are being evaluated to determine optimum grass length and cutting schedules that will reduce the amount of attractive bird habitat on the airport.
- Wildlife Enhancement proposals for Iona Beach Regional Park are not entirely consistent with the SICA Management Plan in terms of the specific species of birds that are intended to be attracted.
- The overall risk of human injury due to a birdstrike involving any single species of bird specifically from SICA, the Sturgeon Banks WMA, the airport property or with migratory birds is rare.
- The overall risk of human injuries due to a bird strike in the vicinity of the airport is low.
- Monitoring of bird activity on Sea Island provides data that is critical to the planning and evaluation processes for the management of bird hazards at or near Vancouver Airport.

Safety Review of Wildlife Management at
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Abbreviations

08L	Runway 08 Left at Vancouver -- North or new runway
08R	Runway 08 Right at Vancouver -- South or old runway
26L	Runway 26 Left at Vancouver -- South or old runway
26R	Runway 26 Right at Vancouver -- North or new runway
CWS	Canadian Wildlife Service
GVRD	Greater Vancouver Regional District
SICA	Sea Island Conservation Area
SRT	Safety Review Team
WMA	Wildlife Management Area
YVR	Vancouver International Airport

**Safety Review of Wildlife Management at
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1. Introduction

1.1 Background

As a result of the Minister of Transport's commitment to protect or replace habitat impacted by the expansion of Vancouver International Airport (YVR), the Sea Island Conservation Area (SICA) was established. To identify any subsequent hazards to aviation, Transport Canada conducted Safety Reviews of the SICA in 1994 and 1995. In those reviews it was clear that the SICA in itself may not create an undue hazard to aviation, provided that a number of recommendations were met. To confirm the outcome of the recommended mitigation, annual Safety Reviews are conducted. In 1996 the Safety Review was expanded to include Vancouver International Airport and Sturgeon Banks areas on or around Sea Island that may attract wildlife hazardous to aviation¹.

1.2 Objective

The objective of the Safety Review is to continue the risk assessment of the SICA, identify wildlife hazards and system deficiencies at or near Vancouver International Airport, assess the risks associated with any hazards and deficiencies, and assess the adequacy of existing mitigation to the risks.

1.3 System Under Review

The system under review is wildlife activities and the control/management of wildlife at or near Vancouver International Airport².

1.4 Methodology

1.4.1 Location and Date of SSR

The review was held in the 3rd Floor Boardroom, 4611 Cowley Crescent, Vancouver International Airport South from July 23-24, 1997

1.4.2 Risk Assessment Procedure

The team interviewed a number of interested parties in order to identify concerns, obtain factual information and receive suggestions. Information was analyzed in order to identify hazards and risks and to assess existing or proposed mitigation.

The following individuals were interviewed.

Name	Agency
Gary Searing	LGI Limited Environmental Research Associates
Dave Ball	Vancouver International Airport Authority, Landscape and Wildlife Control Officer
Tony Barnard	British Columbia Ministry of Environment
Reggie Ho	Wildlife Habitat Advisory Committee on Compensation
Trish Hayes	Canadian Wildlife Service

¹ See Appendix A - Terms of Reference

² See Appendix B - Vancouver International Airport and Environs

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1.4.3 Definitions

Hazard:	Any condition, event or circumstance that could lead to a loss.
Risk:	The potential consequence of a hazard measured in probability and severity.
Mitigation:	Measures to eliminate the hazard or to reduce the probability or severity of a risk.

1.4.4 Criteria for severity and probability

Following hazard identification, the 1996 Safety Review Team (SRT) identified a number of specific risks for each hazard and assigned a severity level for each individual risk. The SRT then assessed the probability of each risk occurring, based on the collective experience of the team. The 1997 team has reviewed current information and considers that the 1996 analysis remains valid.

Evaluation of the severity of bird strikes included consideration of possible effects on users ranging from single engine piston aircraft to large high bypass jet transports. For that reason, the worst case scenarios are based on the potential consequences for the type of aircraft that is likely to be most severely affected by a strike involving a particular species of bird. The level of severity for each worst case scenario is based on the following criteria:

Category A:	potential for aircraft destruction or loss of life (aircraft occupants and others);
Category B:	potential for major aircraft damage or serious injury;
Category C:	potential for minor aircraft damage or minor injury; and,
Category D:	potential for minimal aircraft damage or minimal injury.

Probability is assigned to the risk occurring at any severity level, and not to the severity level assigned, which represents the worst case scenario. The probability of the risk occurring was labeled as rare, low, moderate or high, and was determined objectively in the light of the collective knowledge and experience of the team members, and the following guiding criteria:

High:	very likely under normal circumstances;
Moderate:	likely under normal circumstances; and,
Low:	unlikely under normal circumstances;
Rare:	very unlikely under normal circumstances.

1.5 Safety Review Team Composition

Team Leader:	David Andersen Regional Aviation Safety Officer Transport Canada Pacific Region
Team Members:	Bruce MacKinnon Wildlife Control Specialist Transport Canada Safety and Security Joe Molnar Regional Aviation Safety Officer Transport Canada Pacific Region

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2. Observations

2.1 General

- Several species of birds reside year round, or for portions of the year, at or near Vancouver International Airport. Population levels and bird behaviour remain essentially the same as was reported in the 1996 Safety Review.
- Migratory birds inhabit the vicinity of the airport at certain times of the year. Population levels and bird behaviour have not changed significantly during the past year with the exception that the Russian Snow geese that congregate in the area to the west of the airport, underlying the approach to runway 08R. Over the past winter, while the population levels have remained fairly stable, the birds tended to be more widely spread over a broader area of the foreshore extending farther north toward the approach to runway 08L.
- For reporting purposes a bird strike is deemed to have occurred when:
 - a pilot reports a bird strike
 - aircraft maintenance personnel identify damage to an aircraft as having been caused by a bird strike
 - personnel on the ground report seeing an aircraft strike one or more birds
 - bird remains, whether in whole or part, are found on an Airside pavement area or within 60 meters (200 feet) of a runway, unless another reason for the bird's death is identified.
- Reported birdstrikes at Vancouver³ are summarized in the following table. It should be noted that the lower number of strikes in 1996 may reflect more stringent adherence to established reporting criteria. The Airport Authority advises that there are a number of additional reports, that cannot be verified as meeting the criteria. If these reports are considered, the number of strikes in the vicinity of the airport rises to 114. It was suggested that many of these kind of occurrences may appear in the official statistics for previous years.

<u>Year</u>	<u>Total Movements (1000s)</u>	<u>Reported Number of Bird Strikes</u>
1995	301	108
1995	311	98
1996	330	27

2.2 Bird Strikes Associated with Sea Island Conservation Area

Discussion: There may have been a slight reduction in bird population in SICA but there are no significant behavioral changes since the 1996 Safety Review. The representative from WHACC provided anecdotal information that suggests that bird populations may be slightly lower this year. It is not clear if this is the result of habitat factors or weather. Formal monitoring of bird activity in SICA by LGL Environmental Research Associates indicates that fluctuations in population and movement patterns are relatively small.

Mitigation: The SICA Management plan calls for strip mowing of some old field habitat area. This mowing is intended to encourage populations of certain species in order provide an adequate food supply for raptors that reside in the area. The Management Plan also calls for CWS to post

³ TP577 Aircraft Movement Statistics

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signs that are intended to discourage people from entering the area and disturbing the birds. The SRT observed that this mowing has not taken place and that signs have not been erected.

The CWS representative indicated that mowing is expected to take place later this summer. The agency also expects to receive the proceeds of a lease for a telecommunications facility that lies within the area. They feel that the resulting revenue will be adequate to defray cost incurred in meeting the Management Plan in future years.

Evaluation: The 1996 Safety Review observed that "the Sea Island Conservation Area Management Plan appears well designed to minimize the likelihood of collision between aircraft operating at Vancouver International Airport and birds that reside in SICA. The current SRT is concerned that if the management plan is not followed this goal may be compromised over time. Specifically there is a risk that:

- If habitat is not adequately maintained, some raptors may leave the SICA lands in order to hunt, possibly resulting in collisions with aircraft.
- If SICA resident birds are disturbed by people or vehicles they may leave the SICA and move onto the airport property.

Based on the number of bird strikes that occur relative to the number of aircraft movements at YVR, the probability of collisions between aircraft operating at Vancouver International Airport and individual species of birds that reside in SICA is considered to be rare. Cumulatively, the probability of a strike involving any birds residing in SICA is also considered to be rare. Severity is assessed as Category B (potential for major aircraft damage or serious injury) for arriving aircraft and Category A (potential for aircraft destruction or loss of life) for departing aircraft. This assessment is unchanged from last year. The report of the 1996 Safety Review Team contains a detailed assessment of probability and severity for each species of bird found in the SICA.

2.3 *Bird Strikes Associated with Birds on Vancouver Airport Property*

Discussion: Vancouver International Airport has been acutely aware of potential bird strike hazards and has had an active wildlife control program for many years. Continued monitoring of bird activity has been undertaken in the vicinity of the airport to obtain data that will help assess the effectiveness and appropriateness of these measures⁴.

There were some 330,000 aircraft movements at Vancouver International in 1996. During this same period it is estimated that the wildlife control program involved almost 1,000,000 birds.

Mitigation: Wildlife control efforts are directed into active control and habitat management.

- Wildlife patrol officers harass birds with cracker shells and pyrotechnics. Occasionally, a few birds are killed in order to prevent the program from becoming ineffective due to the birds losing their fear of the wildlife officers and their techniques. Since the spring of 1996 wildlife patrols have operated 24 hours per day. In September 1996 the program was expanded with a second patrol being used to cover areas adjacent to the new runway. Currently, there are plans to eliminate the second patrol from late evening to early morning because the north parallel runway is not in use at those times.

The Airport Authority intends to make the wildlife patrol routes more random in nature, giving officers more flexibility in pursuing birds until they leave the airport property, and to make it more difficult for birds to recognize wildlife patrol vehicles.

⁴ Avian Ecology and Air-Traffic Safety at Vancouver International Airport: Monitoring, LGL Limited Environmental Research Associates, June 1996.

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The airport has obtained propane cannons and is testing their effectiveness on certain areas of the field. In addition they plan to obtain "bird distress" recordings that are recorded in the area and may prove to be more effective than similar tapes which have been used in the past.

- Habitat modifications⁵ are planned that will make the airport less hospitable to a wide variety of bird species. Elimination of standing water and introduction of taller grasses are the principle measures that are planned. These changes involve leveling and re-seeding of large areas of the airport and will take several years before they are fully implemented.

Test plots of Reed Canary Grass are being evaluated to determine optimum cutting schedules that will discourage birds without inducing other environmental or operational problems. Over time, significant portions of the airport are expected to be planted with this grass.

The airport is treating shorter grass areas adjacent to runways and taxiways with certain compounds that will significantly reduce or eliminate worms and other insects. The intended effect of this action is to discourage birds from foraging in these areas.

Improvements to drainage and covering or screening of ditches are proposed in order to discourage birds, particularly waterfowl, from settling on open ditches or areas of standing water.

Evaluation: The active pursuit of birds on the airport is an integral part of the wildlife control program. However, in the past, birds have often been moved from one area of the airport to another without reducing overall population on the airport. It appears that the Wildlife Management Program currently under development will take a more comprehensive and aggressive approach to this component of the program. This should result in more birds being permanently driven away from the airport environs.

Airport habitat modifications will, when fully implemented, significantly reduce bird populations by making the area less attractive. It appears that the proposed use of long grasses on the airport supports several of the recommendations that were made in previous reports.

Based on the number of bird strikes that occur relative to the number of aircraft movements at YVR, the probability of collisions between aircraft operating at Vancouver International Airport and individual species of birds that reside on the airport property is considered to be rare. Cumulatively, the probability of a strike involving any birds residing on the airport property is also considered to be rare. Severity is assessed as Category B (potential for major aircraft damage or serious injury) for arriving aircraft and Category A (potential for aircraft destruction or loss of life) for departing aircraft. The report of the 1996 Safety Review Team contains a detailed assessment of probability and severity for each species of bird found on the airport.

2.4 *Bird Strikes Associated with Sturgeon Banks Wildlife Management Area*

Discussion: The British Columbia Ministry of Environment has developed a Management Plan for the Sturgeon Banks Wildlife Management Area (WMA)⁶. It includes the intertidal and nearshore subtidal areas of the lower Fraser River and Sturgeon Banks between Iona Island and the Fraser River Jetty.

The Management Plan recognizes that aviation safety shall not be compromised by any actions taken to protect or encourage wildlife or new bird populations in the area. It also recognizes the requirement to limit or control bird populations within the WMA in the interests of aviation

⁵ See Appendix C - Airport Field Test Areas

⁶ See Appendix B - Vancouver International Airport and Environs

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safety. The plan does not contemplate any habitat enhancement activities in the foreseeable future.

Mitigation: There is no mitigation in place to deal with bird populations in the foreshore area to the west of Vancouver International Airport.

Evaluation:

The 1996 Safety Review contained a strong recommendation that action be taken to prevent Russian Snow geese from wintering in portions of Sturgeon Banks Wildlife Management Area near the airport approach and departure paths. This hazard has been thoroughly documented as far back as the 1995 report of The Blue Ribbon Panel on Wildlife and Aviation Safety. Active control measures have been taken against these birds within the airport boundaries but, to date, nothing has been done in the area west of the airport fence.

The Airport Authority feels that it requires a permit to undertake control action and CWS seems to be requesting certain detailed information prior to issuing such a permit. The Blue Ribbon Panel Report recognized the immediacy of this hazard and appears to include most of the information that was requested by CWS in a letter to the Airport Authority dated February 7, 1997. The Blue Ribbon Panel Report was accepted by Transport Canada, Vancouver International Airport Authority, the Canadian Wildlife Service and other parties and was signed off at various levels up to the Acting Assistant Deputy Minister of Airports Group. The panel report said, "Transport Canada, the Canadian Wildlife Service and the Coast Guard should immediately begin to work together to deal with the potential hazard posed by the presence of Snow geese on and near the Airport".

Although the probability of a birdstrike involving Snow geese is assessed as rare, the potential effects are assessed as Category A (potential for aircraft destruction and loss of life.) The most vulnerable aircraft are heavily laden, wide bodied aircraft departing from runway 26L. Many of these aircraft are very low when passing over the area in question and the possibility of a mass liftoff by these birds at a critical moment is always present. In view of the potential severity of an aircraft accident that might be caused by Snow geese, the SRT wishes to express, in the strongest possible terms, its concern with the continuing lack of action on the part of these agencies toward resolving this hazard.

Based on the number of bird strikes that occur relative to the number of aircraft movements at YVR, the probability of collisions between aircraft operating at Vancouver International Airport and individual species of birds that reside in the proposed Sturgeon Bank WMA is considered to be rare. Cumulatively, the probability of a strike involving any birds residing in the proposed Sturgeon Bank WMA is also considered to be rare. Severity is assessed as Category B (potential for major aircraft damage or serious injury) for arriving aircraft and Category A (potential for aircraft destruction or loss of life) for departing aircraft. The report of the 1996 Safety Review Team contains a detailed assessment of probability and severity for each species of bird found in the WMA.

2.5 *Bird Strikes Associated with Iona Beach Regional Park*

Discussion: The Greater Vancouver Regional District is planning habitat enhancement to portions of Iona Beach Regional Park². There are a number of proposed enhancements that are intended to clean up the area and encourage birds that are native to the area. One of these projects is intended to attract ducks and geese to the park. Another proposal involves salmon rearing

² See Appendix B - Vancouver International Airport and Environs and Appendix D - Iona Island Regional Park Options For Wildlife Enhancement

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channels which may have the unintended effect of attracting eagles to the park. In both cases, there is a potential to attract species which may cause a hazard to aircraft.

Mitigation: There is no control program designed to deal with birds that may be hazardous to aircraft associated with this area.

While most of the proposed enhancements involve a small number of birds belonging to species that are not likely to affect airport safety, two of the proposals may encourage birds that are much less compatible with aircraft. One proposal is intended to attract ducks and geese and the other, a set of salmon rearing channels, may attract eagles to Sea Island. These species are viewed as hazardous to aircraft and considerable effort has gone into discouraging their presence on Sea Island. Eagles also have the potential to flush large numbers of Snow geese (referred to in section 2.4) into the air suddenly and unpredictably. For these reasons the SRT feels that it is imperative that the GVRD adopt the same aviation safety principles that were so painstakingly developed for the SICA.

Evaluation:

Based on the number of bird strikes that occur relative to the number of aircraft movements at YVR, the probability of collisions between aircraft operating at Vancouver International Airport and individual species of birds that reside in Iona Beach Regional Park is considered to be rare. Cumulatively, the probability of a strike involving any birds residing in the park is also considered to be rare. Severity is assessed as Category B (potential for major aircraft damage or serious injury) for arriving aircraft and Category A (potential for aircraft destruction or loss of life) for departing aircraft.

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3. Underlying Factors

3.1 *Environmental Factors*

Vancouver Airport and environs has always been an attractive habitat for wildlife. Birds have historically been found in wide variety and large numbers in the area. Significant wildlife habitat is constantly being lost to increasing urbanization in the Lower Fraser Valley Area but Sea Island, Iona Island, segments of the west Richmond and areas along the North and Middle Arms of the Fraser River remain relatively unoccupied. As a result they are particularly attractive to birds. For these reasons, control of wildlife populations and their behaviour in the airport vicinity will require concerted effort on a continuing basis.

3.2 *Bird Population and Movement Data*

Information about bird movements and population levels is a key requirement for development and maintenance of an effective wildlife management program as is the availability of reliable information on bird locations, numbers, movements, and behaviour. Data from SICA, Sturgeon Bank WMA and the airport property collected on a continuing long term basis will reveal population trends for different species of birds in various areas around YVR. Such monitoring permits:

- Maximizing the effectiveness of its wildlife control program by concentrating on those species whose numbers represent the greatest potential risk to users.
- Assessment of which wildlife control techniques have the greatest value in dealing with various species of birds.
- Analysis of whether or not the wildlife management goals in SICA, Sturgeon Banks WMA and Iona Beach Regional Park are being met.

3.3 *Management of Operational Risk*

Several processes are in place to support effective management of the continuing operational risks related to wildlife activities at and near Vancouver International Airport. They include:

- Annual Safety Reviews.
- A risk management program to ensure the safe coexistence of the Airport and the Sea Island Conservation Area involving Transport Canada, Environment Canada and the Vancouver International Airport Authority. This process was originally recommended by the Blue Ribbon Panel.
- The Airport Wildlife Control Committee, the SICA Management Steering Committee, and the SICA working Group.

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4. Conclusions

The team assessed the potential severity of birdstrikes on the basis of the size of individual birds and/or the size of flock of various species that are likely to be encountered. Based on historical information regarding the outcome of birdstrikes, the consequences of a strike involving a departing aircraft are much more likely to be catastrophic (Category A) than is a strike involving an arriving aircraft (Category B.) In particular, the SRT felt that, should multiple bird strikes of Snow gees be incurred by a departing jet, the most likely result would be catastrophic.

The Safety Review team concluded that the risk of birdstrikes involving any single species of bird specifically from SICA, the Sturgeon Banks WMA, Iona Beach Regional Park, the airport property or with migratory birds was rare. They further concluded that the overall risk of a bird strike in the vicinity of the airport was low.

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Appendix A -- Terms of Reference

Terms of Reference

**SAFETY REVIEW
of
WILD LIFE MANAGEMENT
in the vicinity of
VANCOUVER INTERNATIONAL AIRPORT**

BACKGROUND

As a result of the Minister's (of Transport) commitment to protect or replace habitat impacted by the expansion of Vancouver International Airport, the Sea Island Conservation Area (SICA) was established. To identify possible resulting hazards to aviation, Transport Canada conducted Safety Reviews of the SICA in 1994 and 1995. In those reviews it was clear that the SICA in itself may not create an undue hazard to aviation, provided that a number of recommendations were met. However, to monitor the success of the recommended mitigation, annual Safety Reviews are conducted. Although the 1995 and 1996 Safety Reviews were limited to the SICA, Sea Island and the Sturgeon banks also attract flocks of water fowl, that could present a risk to aviation. Therefore, in 1996, the Regional Director General Aviation directed that the SICA Safety Review should be expanded to include other areas on, and adjacent to, Vancouver International Airport.

OBJECTIVE

The objective of the 1997 Safety Review is to:

- identify wildlife hazards and system deficiencies,
- assess the risks associated with identified hazards and deficiencies, and
- assess the adequacy of mitigation in place to deal with identified risks.

SYSTEM

The system under review includes all wild life activities and associated wildlife control and management strategies within:

- SICA,
- Vancouver International Airport,
- Sturgeon banks, and
- all areas on or around Sea Island that might attract wildlife hazardous to aviation.

AUTHORITY

As authorized by Sub-Section 4.2 of the Aeronautics Act.

TEAM COMPOSITION

Team Leader	David Andersen ATS Safety Specialist Transport Canada Pacific Region

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Appendix A -- Terms of Reference

Team Members: Bruce MacKinnon
 Manager, Wildlife Control
 Safety & Technical Services
 Transport Canada, Airports

 Joe Molnar
 Regional Aviation Safety Officer
 Transport Canada, Pacific Region

RESPONSIBILITIES

To gain timely information that would reveal hazards and system deficiencies and to report these to the Regional Director Civil Aviation (Pacific), Transport Canada.

METHODOLOGY

The SRT will :

- review and analyze the data collected on bird population and movement;
- assess the implementation and effectiveness of the wildlife control program for areas adjacent to YVR as identified in the 1996 safety Review;
- assess the implementation and effectiveness of the wildlife control program at YVR as identified in the 1996 safety Review;

in order to identify hazards, assess associated risks, evaluate mitigation and produce a report of their findings.

TIMING

This Safety Review will be conducted during the month of July producing a final report thereafter.

COST

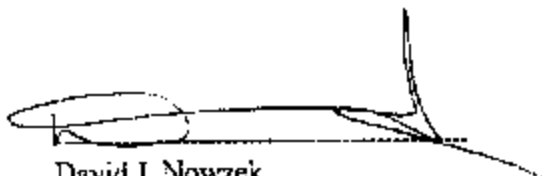
Each organization will be responsible for all costs incurred by their respective staff.

REPORT

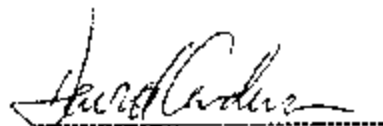
A report documenting the Safety Review Team's observations will be provided to the Regional Director Civil Aviation, on or before 97 August 31. A copy will be provided to the Director Safety Programs, Transport Canada. Additional copies will be available for stake holders.

FOLLOW-UP

As part of its ongoing responsibility to review the planning and execution of Transport Canada Aviation's responsibilities, System Safety will follow-up on its observations and record any mitigating action.



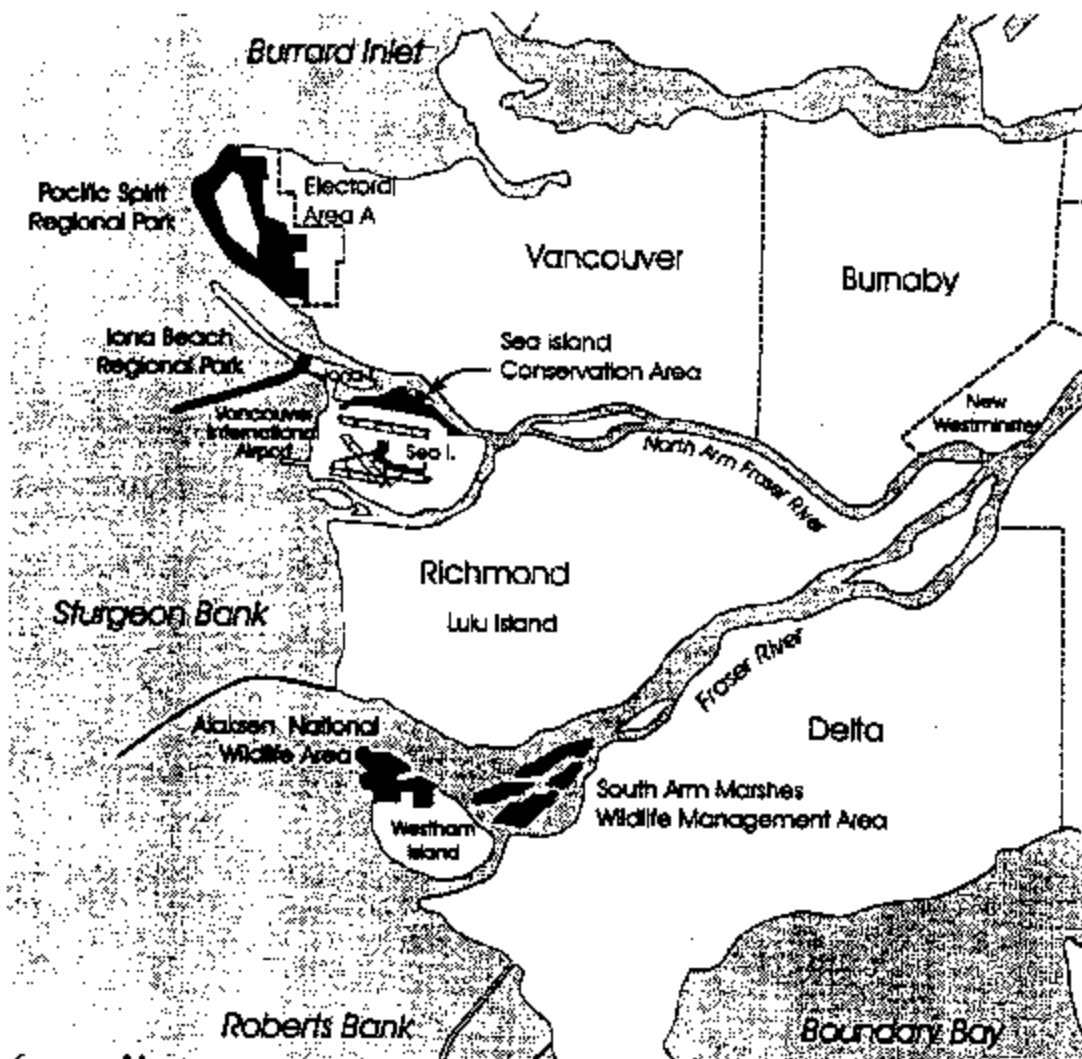
David J. Nowzek
Regional Director Civil Aviation
Transport Canada (Pacific Region)



David Andersen (Team Leader)
ATS Safety Specialist
Transport Canada (Pacific Region)

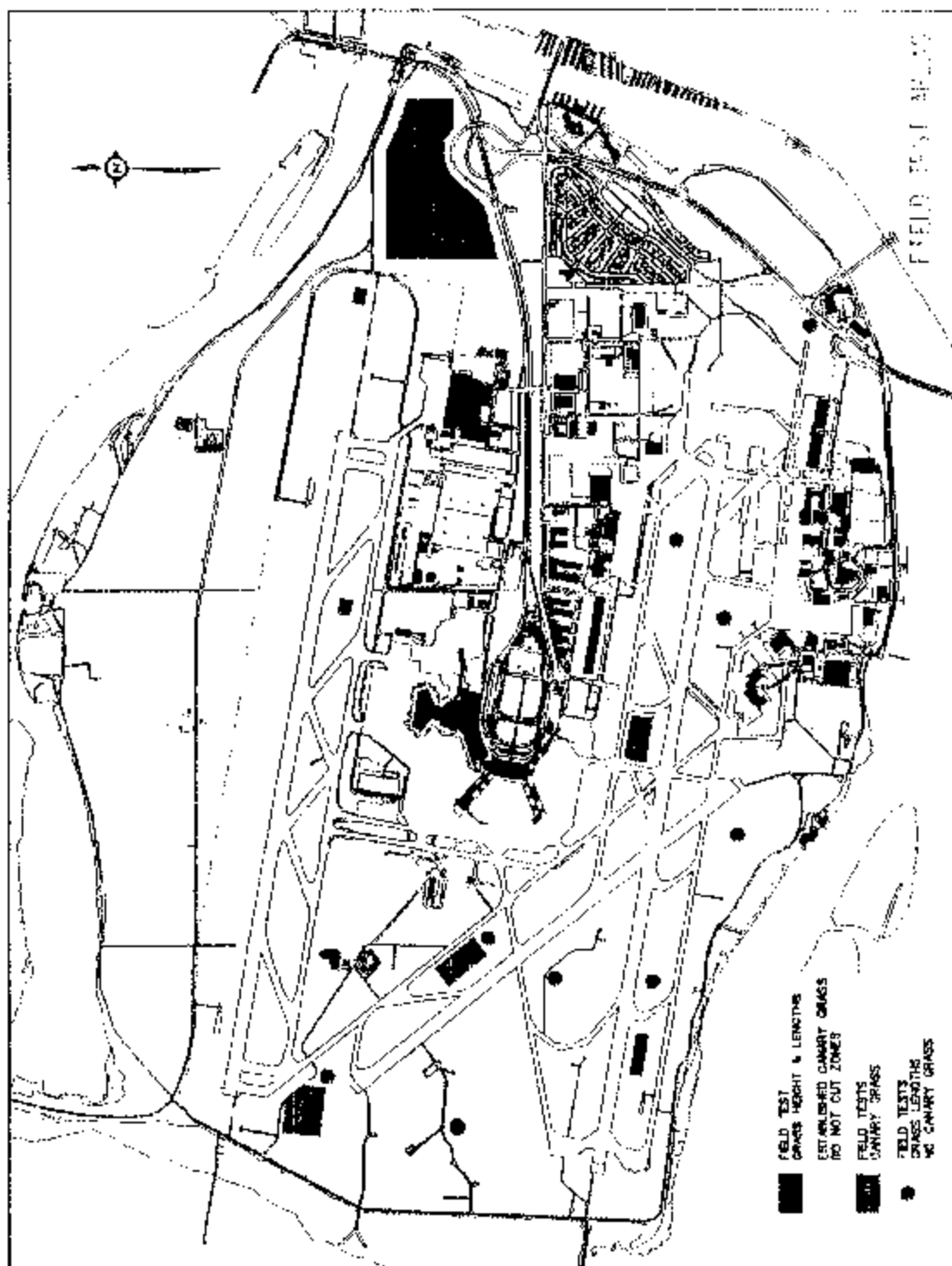
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Appendix B -- Vancouver Airport and Environs



Safety Review of Wildlife Management at
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Appendix C -- Vancouver Airport Field Test Areas



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APPENDIX D -- IONA ISLAND REGIONAL PARK
OPTIONS FOR WILDLIFE HABITAT ENHANCEMENT

IONA BEACH REGIONAL PARK
OPTIONS FOR WILDLIFE HABITAT ENHANCEMENT

July 1997

Prepared by D. Colnett, Wildlife Habitat Program Coordinator and GVRD Parks, West Area

This document outlines options to enhance avian habitat on lands owned by GVRD Parks on Iona Island. These options are proposed for implementation as part of the Wildlife Habitat Enhancement Program (WHEP), which is co-managed by Environment Canada and GVRD Parks and funded through the Airport Habitat Compensation Fund. The Program's goal is to increase habitat capability for a greater number of raptors, herons, songbirds and waterbirds in selected Greater Vancouver parks and conservation areas.

These options were discussed at a June 19th meeting on concept planning for the Park. Representatives from the following groups and agencies attended this meeting and generally supported the options: Wild Bird Trust of BC, BC Ministry of Environment, Canadian Wildlife Service and YVR. With regards to the fish rearing channel, the YVR representative requested more information about design parameters and potential effects on bird populations.

BASE OF NORTH ARM JETTY (MAP 1)

1. Interplant trees and shrubs among designated stands of broom, close to berm.
Species to plant include: Shore pine, Oregon grape, Nootka and Baldhip roses, Mountain ash and Elderberry.

Expected results: Greater diversity of vegetation will provide improved shelter and feeding opportunities for passerines such as American Robin, Common Yellowthroat, sparrows, wrens, vireos, and blackbirds.

Considerations for aircraft safety: Given the exposed site conditions, the vegetation is likely to remain compact and grow slowly. Therefore, the plantings are unlikely to provide roosting sites for flocking birds such as starlings and crows.

2. Remove log debris around brackish marsh, focusing efforts below the high tide line.
(First, we would investigate whether log debris is negatively impacting intertidal vegetation and invertebrates and the probable rate of re-invasion).

Expected results: Improving the productivity of the marsh would increase the site's carrying capacity for gulls, ducks and shorebirds.

Considerations for aircraft safety: Improved feeding opportunities at this site would provide an alternative for birds that frequent the foreshore around Sea Island.

3. Plant shrubs along Iona Island's north shore.
Species to plant include: cascara, willows and nootka and baldhip roses.

Expected results: The new vegetation would provide a more secure east-west movement corridor for migratory passerines such as warblers and flycatchers.

Considerations for aircraft safety: This planting is targeted at passerines.

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AROUND THE PONDS (MAP 1)

4. Plant more bulrushes along the South Pond's north shore. (area about 150 m by 3 m).

Expected results: Increase nesting opportunities for yellow-headed blackbird, marsh wren, red-winged blackbird and some shorebirds.

Considerations for aircraft safety: The target species already nest in the area and numbers of nesting pairs would not increase significantly.

5. Increase the diversity of hedgerow species along the fence between the Park and STP.
Species to plant include: cascara, elderberry, mountain ash, oregon grape and nootka and baldhip roses.

Expected results: The additional plants (about 75) would provide more feeding and resting opportunities for migratory passerines.

Considerations for aircraft safety: This site is already used as a movement corridor by migrating passerines.

6. Work towards broom eradication in the area around the ponds and on the islands.

Expected results: Reduce the competition with native species and allow for greater expanses of grasslands. This would allow birds to more effectively utilize this area.

Considerations for aircraft safety: not needed.

7. Install signage to explain habitat sensitivity. Consider seasonal closures.

Expected results: People are less likely to disturb nesting birds resulting in higher reproduction success for solitary sandpipers, ducks, coots and blackbirds.

Considerations for aircraft safety: This area does not provide nesting habitat for "problem" species such as crows, starlings or geese. Therefore, the populations of these species will not be affected.

EAST PENINSULA/ CANFOR POINT (MAP 2)

8. Develop a salmon rearing channel just east of the existing channels. Main channel to be about 350 m long, about 3 m wide and averaging 1 m depth. Three channels would be about 15 m long and connect with existing tidal area. Tides are expected to provide water about 60% of the time.

Expected results: The channels would provide additional foraging opportunities for Great Blue Herons.

Considerations for aircraft safety: this enhancement is not expected to attract "problem" species.

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9. Remove broom from a well defined area (~1 ha) and replace with medium-height grass field.

Expected results: The small field area would provide additional foraging opportunities for passerines that frequent the existing hedgerows and thickets. The field may also provide vole habitat and eventually contribute to additional foraging opportunities for wintering hawks.

Considerations for aircraft safety: Because the grass would not be mowed, it is unlikely to attract starlings or geese.

10. Interplant trees and shrubs along the north margin of the marsh to connect with existing hedgerows. Species to plant include: Cascara, Elderberry, Mountain ash, Pacific crabapple, Black twinberry, willows and nootka and baldhip roses.

Expected results: The new vegetation would provide a more secure east-west movement corridor for migratory passerines such as warblers and flycatchers. Trees and shrubs would also provide feeding and nesting habitat for passerines.

Considerations for aircraft safety: This option is targeted at passerines.

WOODLOT AT EAST END (MAP 2)

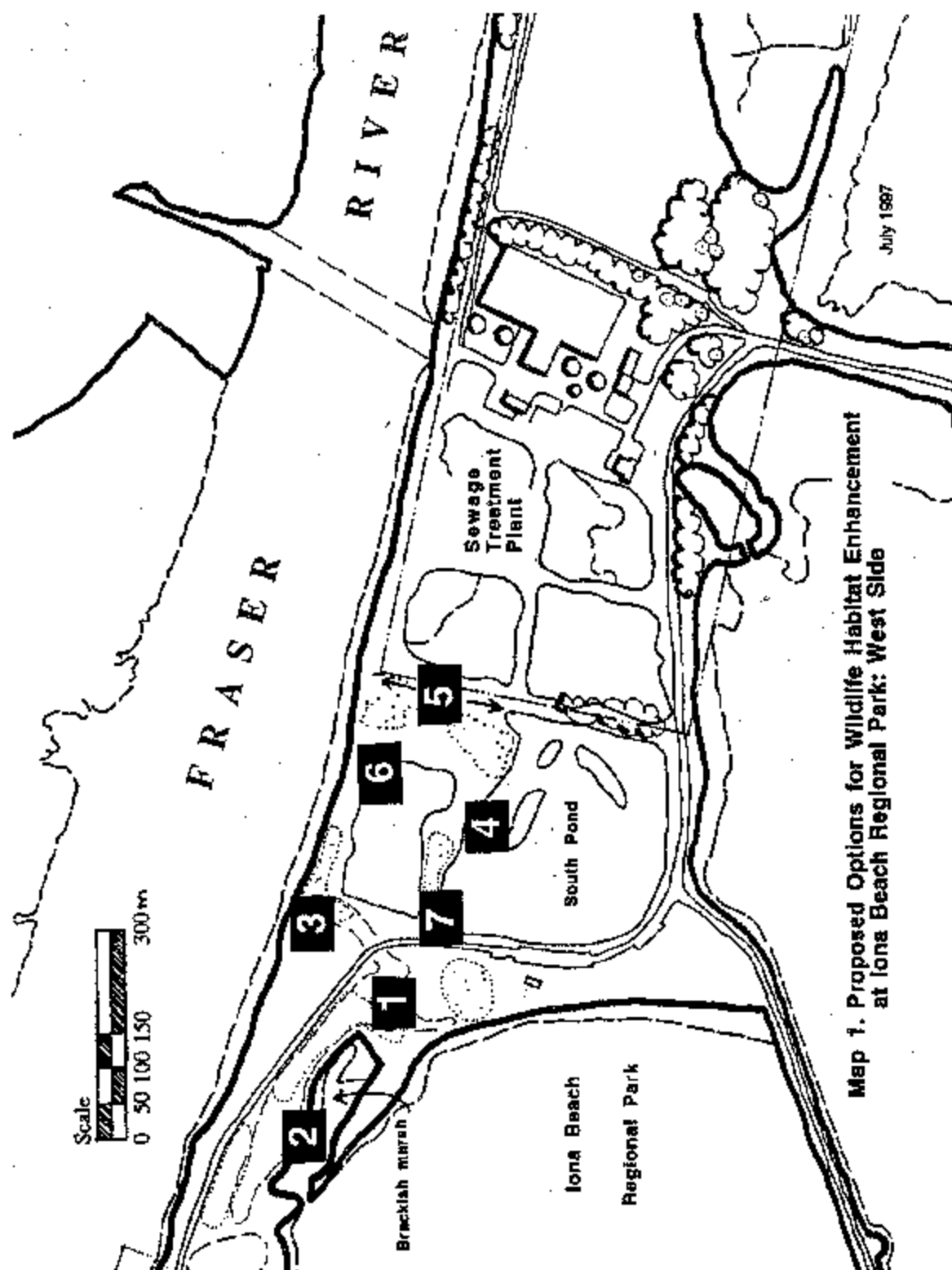
11. Plant trees and shrubs in the woodlot to create more diversity in the understory. Species to plant include: Douglas Fir (5%), Bitter Cherry, Indian Plum, Vine Maple, Black twinberry, nootka and baldhip roses and salmonberry.

Expected results: A greater diversity in the type and height of vegetation in the woodlot would allow for use by a greater variety of bird species. The new vegetation would provide feeding, nesting and resting opportunities primarily for passerines.

Considerations for aircraft safety: This option is targeted at passerines.

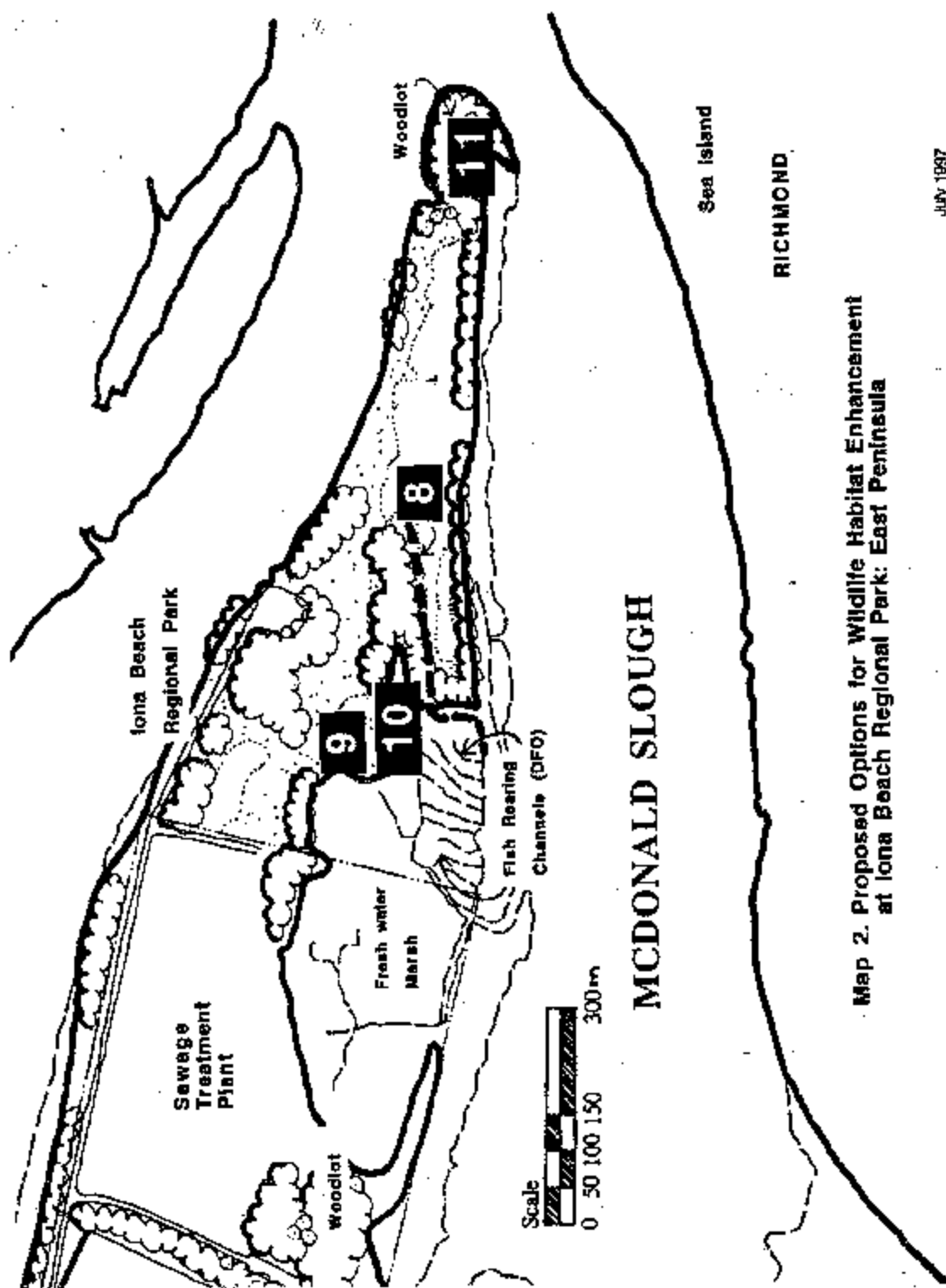
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Appendix E -- Supporting Documents

Document	Description
A Draft Plan for Monitoring Birds at the Vancouver International Airport and Vicinity	Discussion paper prepared by Gary Searing, LGL Limited Environmental Research Associates - 22 July 1996
A Handbook for the Control of Problem Canada Geese	An Environment Canada Publication that describes various methods of dealing with nuisance Canada Geese.
Bird Strikes to Canadian Aircraft 1991 through 1996 Summary Reports TP5073E	Comprehensive birdstrike data from several major Canadian Airports.
Blue Ribbon Panel On Wild Life an Aviation Safety	Report on Transport Canada's response to Federal Environmental Assessment and Review Panel Report #40 and Other Issues on the Parallel Runway Project at Vancouver
System Safety Review of Bird Hazards Related to the Sea Island Conservation Area	Report of previous review team dealing with issues specific to SICA
Wildlife Management at YVR and Environs	Report of A System Safety Review 1996

APPENDIX 29

Caribou and Aircraft Overflights

Caribou and Aircraft Overflights



Caribou are found throughout the northern boreal forest, taiga and tundra areas of Canada and Alaska. They are known as nomadic herd animals and make long-distance seasonal migrations, particularly in the spring and autumn. Caribou usually remain in social groups and on the move during the rest of the year. Their largest groups are formed in the summer after the calving season ends (late June or early July), but they can be encountered in groups of hundreds or even thousands at any time of the year. Caribou appear to function in more or less discrete populations, often referred to as herds, and the breeding females of each population tend to collectively exhibit a strong affinity for their specific calving area(s).

There is a consensus among caribou wildlife biologists that the most sensitive times of the year for the herd, especially female caribou and their young calves, are during the calving and post-calving periods. Calving can occur at any time from late May to early July. The actual peak of calving ranges from between seven and ten days to two weeks in length and most often occurs in early to mid-June, with some annual variation among populations. Newborn calves remain totally dependent upon their mothers' milk for nourishment from July through September and benefit from additional nursing during October and November. Therefore, concern about aircraft overflights is greatest from

May to November. These flights have a serious impact on the well-being of caribou, especially the mothers and their young calves.

Wildlife biologists recommend that a minimum altitude of 1000 ft. AGL be adhered to whenever possible when caribou are encountered. This is particularly important during the late spring and early summer. Calves can become separated from their mothers when disturbed by something new in their environment, such as low-flying aircraft. Any separation of the young calves from their mothers, even for short periods of time, could be lethal: predators such as wolves and bears are often close by herds of caribou, and separated calves are easy prey as the calves have not yet learned the necessary survival skills. When deprived of their mothers' milk, calves will quickly become undernourished and weak and will usually fall prey to predators, starve or die of exposure. In addition, when large herds that are highly agitated or panicky engage in panic manoeuvres to escape real or imagined dangers, many animals, particularly calves and yearlings, can become crippled; broken legs are a common result of such events.

Since a great deal of northern activity requires flight at altitudes below 1000 ft. AGL, helicopter pilots should observe the following recommendations when caribou are encountered, particularly from May to November:

- Fly around caribou herds whenever possible when flying at less than 1000 ft. AGL.
- Don't dive down on caribou groups or individual animals for a closer look.
- If paying customers ask you to make a low pass so that they can take pictures or get a closer look, say no.

*Many thanks to
Stuart McDonald,
Canadian Wildlife Services*

APPENDIX 30

Stowaway Starling

Stowaway Starling

Taking a bird for an unintentional ride

Mike Dillard

Any pilot who says he (or she) has never watched a bird in flight definitely lacks a romantic streak. They probably think Richard Bach's book about the seagull is just a nature text or some spiritual gobbledygook.

Romantic or not, those of us who fly develop a healthy respect for birds when they get around our airplanes. Although I haven't met a bird in flight (and I hope never to have the experience), I have had an encounter with one.

One late summer afternoon I was preflighting a Cessna 172 and checking for bird nests before a sunset flight with my 11-year-old daughter, Megan. I'd opened both doors to cool the cabin as we did our walk-around, and then a pilot friend called to us. We stepped away from the Cessna, talked about the good flying weather, he joshed Megan about flying with her old man, and we parted with him wishing us a good time.

We completed the preflight, took off, and flew over a glass-like James River. It was one of those hot, still evenings, with some haze that's so common in Tidewater Virginia. Without air conditioning it would be an uncomfortable night on the ground, but it was a pleasant night to fly. We started with a little navigation work and tried to find a landmark from the chart. Megan made a few turns, with Dad helping on the rudders, and then we flew up the York River as she tried to hold a course with my hands resting gently on the yoke, "helping her, just a little."

At West Point Airport I made a few landings, the first being a real thud and bump. The others were a lot softer and redeemed me in my daughter's eyes (and in my own). We'd chatted and



Any time you see a bird roosting on your airplane—beware. You never know if it—or its friends—are stowaways looking for a free ride.

laughed and looked down at those poor unfortunate groundlings who weren't sharing our joy. As the sun edged the horizon, we turned back for the James River, Williamsburg-Jamestown Airport, and home.

My landing at Williamsburg was the best of the evening, a perfect ending to a near-perfect flight. As I taxied off the runway and retracted the flaps a sudden commotion from the back seat intruded into my headset. "Dad, there's a bird in here!" Megan shouted into the intercom. I held the brakes, looked over my shoulder, and saw a mass of feathers flapping and scratching like a frenzied feather duster trying to clean a hole through the back window.

"How did it get in here?" Megan shouted again, echoing my own thoughts.

The agitated bird was getting closer as it moved to the side window behind my head. "Okay, just hold on sweetheart," I said trying to keep her calm. I was trying to keep myself calm too, since my hands were still full of Cessna.

"Let Megan out of the plane?" I thought.

"No, there's a big spinning prop out there. Keep her where she is," I concluded.

We cleared the taxiway turnoff, and taxied to the airplane's parking spot, which wasn't too far away. As the bird continued its assault on the left rear-seat window, I went through the engine shutdown procedure as quickly and as calmly as I could. When the prop stopped I told Megan to get out. When she was clear of the Cessna, I took the keys and got out as the bird —

a starling. I noticed — continued to beat itself around the rear of the cabin.

Opening the baggage door finally gave the bird the escape route it wanted, and it flew away at its best possible speed.

"How did it get in there, Dad?" Megan repeated. "Do you think it was hurt?"

"I don't know," I said, looking in the back seat, then checking the rear bulkhead.

It was snug and in place. The bird hadn't come from the tail cone.

Then a thousand thoughts rushed through my mind about the pandemonium a bird bashing around the cockpit of an airplane in flight could have caused. What if the bird had started ramming against my door during flight or while we were landing? Could I have maintained control? Where was the bird and why did it act up only after my fourth and last landing of the flight? Why didn't that first hard landing stir it up?

I looked at my daughter grinning up at me and realized just how lucky we had been.

As I coiled the headset cables and tied down the airplane, I tried to keep my thoughts from showing. I joked with Megan, and she laughed about our "stowaway starling" as we drove home.

Talking with other pilots later, all we could surmise was that the bird had flown unnoticed through the open doors during our preflight conversation with our friend. Perhaps the bird stunned itself by striking the inside of the cabin wall when it flew in and only came to after my last touchdown.

Megan and I still joke about the stowaway starling, but the bird taught me a lesson. During my preflight inspections I still check for birds and nests in all the usual places such as the cowling and tail cone. But now I check inside the cabin, too. No more stowaways for me. I still enjoy watching birds in flight, but I insist they do their flying on their own!



APPENDIX 31

Airport Land Uses Require Planning to Prevent Wildlife-Aircraft Strikes



FLIGHT SAFETY FOUNDATION

Airport Operations

Vol. 23 No. 4

For Everyone Concerned with the Safety of Flight

July-August 1997

Airport Land Uses Require Planning to Prevent Wildlife-Aircraft Strikes

Increased wildlife populations on and around airports and changes in aircraft technology have added to the danger of collisions between wildlife and aircraft. A recent U.S. Federal Aviation Administration Advisory Circular makes many recommendations about land uses on or near airports.

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FSF Editorial Staff

The U.S. Federal Aviation Administration (FAA) has published a new advisory circular (AC) that provides guidance for land use on or near airports so as to minimize the possibility of wildlife-aircraft strikes. AC 150/5200, *Hazardous Wildlife Attractants on or near Airports*, specifies minimum recommended distances between airport areas and wildlife attractants.

The AC defines hazardous wildlife as "species that are commonly associated with wildlife-aircraft strike problems, are capable of causing structural damage to airport facilities or act as attractants to other wildlife that pose a wildlife-aircraft strike hazard."

Although tracts of open land around airports add to the safety margin and reduce noise problems, they can attract species of wildlife that adapt well to such environments.

Other factors also attract wildlife to the airport environment. Chief among them is the use that is made of the land on or near the airport, and it is important for airport operators, planners and land-use developers to be aware of which land-use practices may act as wildlife attractants. Undesirable land-use practices can bring wildlife into the approach or departure airspace, aircraft surface-movement areas and ramp areas of airports.



The increase in wildlife populations, the use of larger turbine engines, the increased number of twin-engine aircraft and the growth of air traffic have all contributed to the growing number and severity of collisions between wildlife and aircraft.

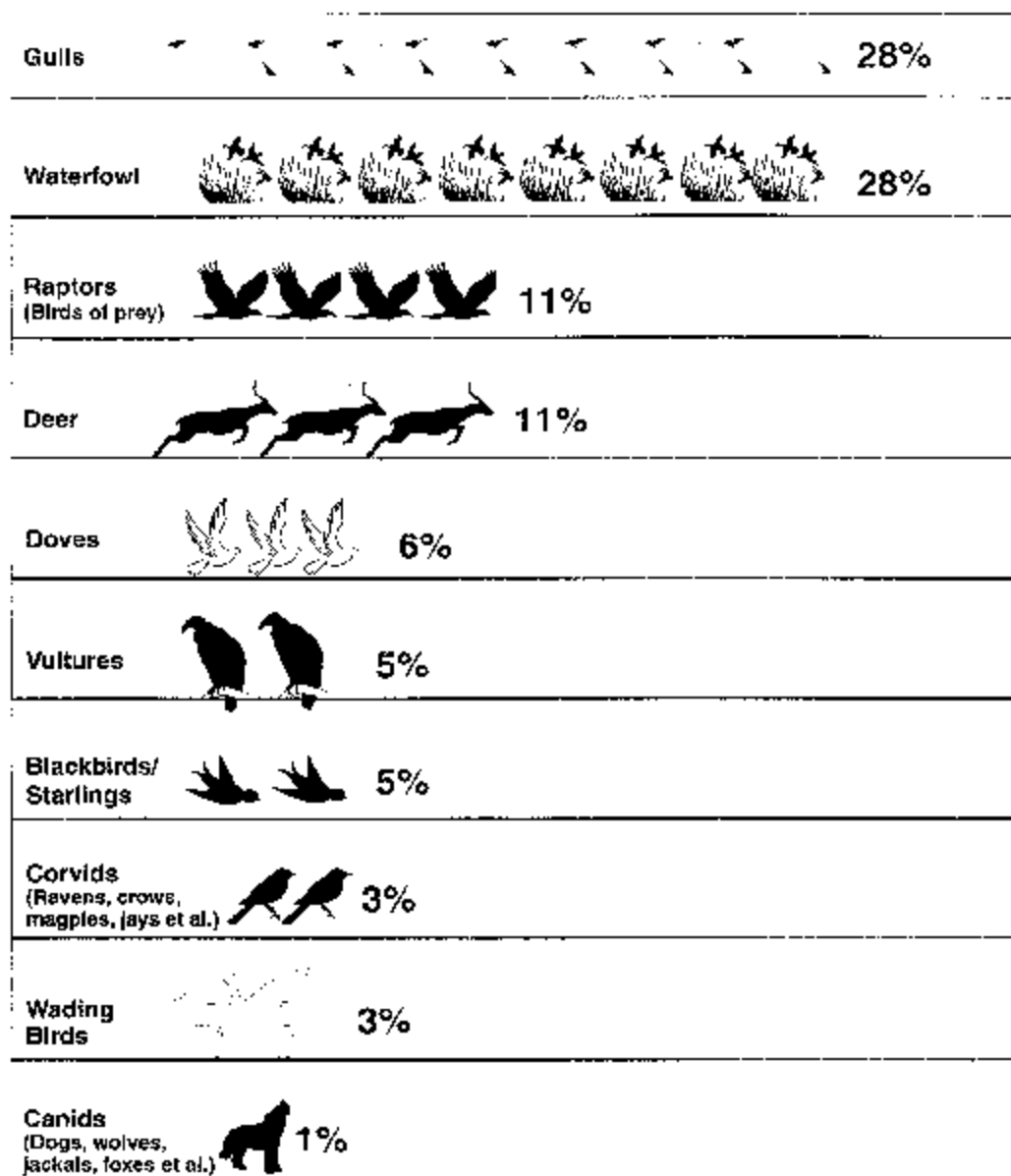
"During the past century," the AC said, "wildlife-aircraft strikes have resulted in the loss of hundreds of lives worldwide, as well as billions of dollars of aircraft damage. Hazardous wildlife attractants near airports could jeopardize future airport expansion because of safety considerations."

Table 1 (page 2) shows groups of wildlife and the percentage of damaging strikes to civilian aircraft in which they were involved from 1993 to 1995.

"Caution should be exercised to ensure that land use practices on or near airports do not enhance the attractiveness of the area to hazardous wildlife," the AC said. "Particular attention should be given to proposed land uses involving creation or expansion of wastewater treatment facilities, development of wetland mitigation sites or development or expansion of dredge-spoil containment areas.

"FAA recommends separations when siting any of the wildlife attractants mentioned in [the AC] or when planning new airport development projects to accommodate aircraft movement. The

Table 1
Wildlife Involved in Reported Strikes with Damage to
Civilian Aircraft, United States, 1993-1995



Groups of wildlife, ranked by percentage, involved in collisions

Percentages total more than 100 percent because of rounding

Source: U.S. Federal Aviation Administration

distance between an airport's aircraft movement areas, loading ramps or aircraft parking areas and the wildlife attractant should be as [shown in Table 2, page 3]."

The AC first discussed land uses that are known to attract hazardous wildlife and thereby create hazards to flight safety. These include putrescible-waste disposal operations, wastewater treatment operations, wetlands and dredge-spoil containment. (See "Definitions," page 4.)

Putrescible material is rotting organic matter. Putrescible-waste disposal operations include landfills, garbage dumps, underwater waste discharges and other facilities for disposing of rotting organic material, trash or refuse. "Putrescible-waste disposal operations are known to attract large numbers of wildlife that are hazardous to aircraft," the AC said.

Wastewater treatment facilities are used to store and reclaim municipal sewage or liquid industrial waste. In most instances,

Table 2
Minimum Recommended Distances
Between Vulnerable Airport
Areas* and Wildlife Attractants

- **Airports serving piston-powered aircraft:** A distance of [1,525 meters (5,000 feet)] is recommended;
- **Airports serving turbine-powered aircraft:** A distance of [3,050 meters (10,000 feet)] is recommended; and,
- **Approach or departure airspace:** A distance of eight kilometers (five miles) is recommended if the wildlife attractant may cause hazardous wildlife movement into or across the approach or departure airspace.

* Aircraft movement areas, loading ramps or aircraft parking areas.

Source: U.S. Federal Aviation Administration

settling ponds are associated with the wastewater treatment facilities.

Wastewater treatment operations are grouped into five categories:

- **New wastewater treatment facilities.** The AC recommended against building wastewater treatment facilities or associated settling ponds within the separations given in Table 2.
- **Existing wastewater treatment facilities.** The AC recommended taking immediate steps to counteract any wildlife hazards that arise from existing wastewater treatment facilities located on or near airports. Operators of the wastewater treatment facilities should incorporate appropriate wildlife-hazard mitigation techniques into their operations. Measures should be developed in consultation with a wildlife damage-management biologist (WDMB).
- **Artificial marshes.** "Wastewater treatment facilities may create artificial marshes," the AC said, "and use submergent (partly submerged) and emergent (mostly above-water) aquatic vegetation as natural filters. These artificial marshes may be used by some species of flocking birds, such as blackbirds and waterfowl, for breeding and roosting activities."
- **Wastewater discharge and sludge disposal.** The AC said, "FAA recommends against the discharge of wastewater or sludge [dewatered effluent] on airport property. Regular spraying of wastewater or sludge disposal on unpaved areas may improve soil moisture and quality. The resultant turf growth requires more frequent mowing, which in turn may mutilate or flush

insects or small animals and produce straw. The maimed or flushed organisms and the straw can attract hazardous wildlife ... In addition, the improved turf may attract grazing wildlife such as deer and geese."

- **Underwater waste discharge.** The underwater discharge of food waste can be a strong attraction for scavenging wildlife.

Wetlands on or near airports pose another type of wildlife-attractant hazard, and the AC addressed three specific issues: existing airports, airport development and wetland mitigation.

- **Existing airports.** "Normally, wetlands are attractive to many wildlife species," the AC said. "Airport operators with wetlands located on or nearby airport property should be alert to any wildlife use or habitat changes in these areas that could affect safe aircraft operations."
- **Airport development.** The AC recommended using the separations identified in Table 2 when siting new airports. The AC said, "Where alternative sites are not practicable or when expanding existing airports in or near wetlands, the wildlife hazards should be evaluated and minimized through a wildlife management plan prepared by a [WDMB], in consultation with the U.S. Fish and Wildlife Service (USFWS) and the U.S. Army Corps of Engineers (COE)."
- **Wetland mitigation.** Under U.S. environmental protection laws, mitigation of a wetlands area (designation of a replacement wetlands area of the same size and quality) may be necessary when new airport development projects result in unavoidable wetland disturbances.

The AC recommended that wetland mitigation projects that could attract hazardous wildlife should be sited outside of the separations identified in Table 2. Exceptions may be considered if the affected wetlands provide unique ecological functions, such as critical habitat for threatened or endangered species. Such mitigation must be compatible with safe airport operations. On-site mitigation plans may be reviewed by the FAA to determine compatibility with safe airport operations.

"Wetland mitigation projects that are needed to protect unique wetland functions ... and that must be located in the siting criteria in [Table 2] should be identified and evaluated by a [WDMB] before implementing the mitigation," the AC said.

Dredge-spoil containment areas. If the dredge spoil contains materials that would attract wildlife, the AC recommended against locating the dredge spoil within the separations identified in Table 2.

Areas on or near airports need not be kept empty or idle in the interest of aviation safety. The AC listed a number of land uses that can be compatible with safe airport operations.

Definitions

Clearway: A defined rectangular area beyond the end of the runway, cleared or suitable for use in place of the runway to satisfy takeoff-distance requirements.

Dredge spoil: Sand, rocks, mud and materials dredged up from the bottom of a body of water and placed on land.

OFA (object-free area): A two-dimensional ground area surrounding runways, taxiways and taxi lanes that is clear of objects except for objects whose location is fixed by function.

OFZ (obstacle-free zone): Includes the airspace above the runway centerline, the airspace above the extended runway centerline (for approach-lighting systems) and the airspace above the outer edges of the first two areas (for precision instrument runways).

RPZ (runway protection zone): A trapezoidally shaped area that is centered on the extended runway centerline. The RPZ dimension for a particular runway is a function of the type of aircraft and the approach visibility minimum associated with that runway end. The OFA is a component of the RPZ.

RSA (runway safety area): A defined ground surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot or excursion from the runway.

RVZ (runway visibility zone): The area that must be visible to a pilot using a runway, including the runway in use and any runways that intersect it.

TSS (threshold siting surface): The threshold siting surface starts at the beginning of the full-strength runway pavement, at the threshold elevation, and slopes upward (away from the runway) from that point at a gradient of 20 (horizontally) to one (vertically). The dimensions of the individual TSS and any displacement of the TSS depend on operational criteria.

Source: U.S. Federal Aviation Administration

Enclosed waste facilities. The AC said, "Enclosed trash-transfer stations or enclosed waste-handling facilities that receive garbage indoors; process it via compaction, incineration or similar manner; and remove all residue by enclosed vehicles, generally would be compatible, from a wildlife perspective, with safe airport operations, provided they are not located on airport property or within the runway protection zone (RPZ). No putrescible waste should be handled or stored outside at any time, for any reason, in a partially enclosed structure accessible to hazardous wildlife."

Recycling centers. "Recycling centers that accept previously sorted, nonfood items such as glass, newspaper, cardboard or aluminum are, in most cases, not attractive to wildlife," the AC said.

Composting operations. The AC did not recommend that composting operations occur at airports. If they do, however, the AC said that they should be at least 366 meters (1,200 feet) from any aircraft movement area, loading ramp or aircraft parking space, or the distance called for by airport design requirements, whichever is greater. This separation is intended to prevent composting operations material, personnel or equipment from penetrating any obstacle-free area (OFA), obstacle free zone (OFZ), threshold siting surface (TSS) or clearway.¹

"Components of the compost should never include any municipal solid waste," the AC said. "Nonfood waste such as leaves, lawn clippings, branches and twigs generally are not considered a wildlife attractant."

The AC called for the airport operator to monitor composting operations "to ensure that steam or thermal rise does not affect air traffic in any way. Discarded leaf-disposal bags or other debris must not be allowed to blow onto any active airport area. Also, the airport operator should reserve the right to stop any operation that creates unsafe, undesirable or incompatible conditions at the airport."

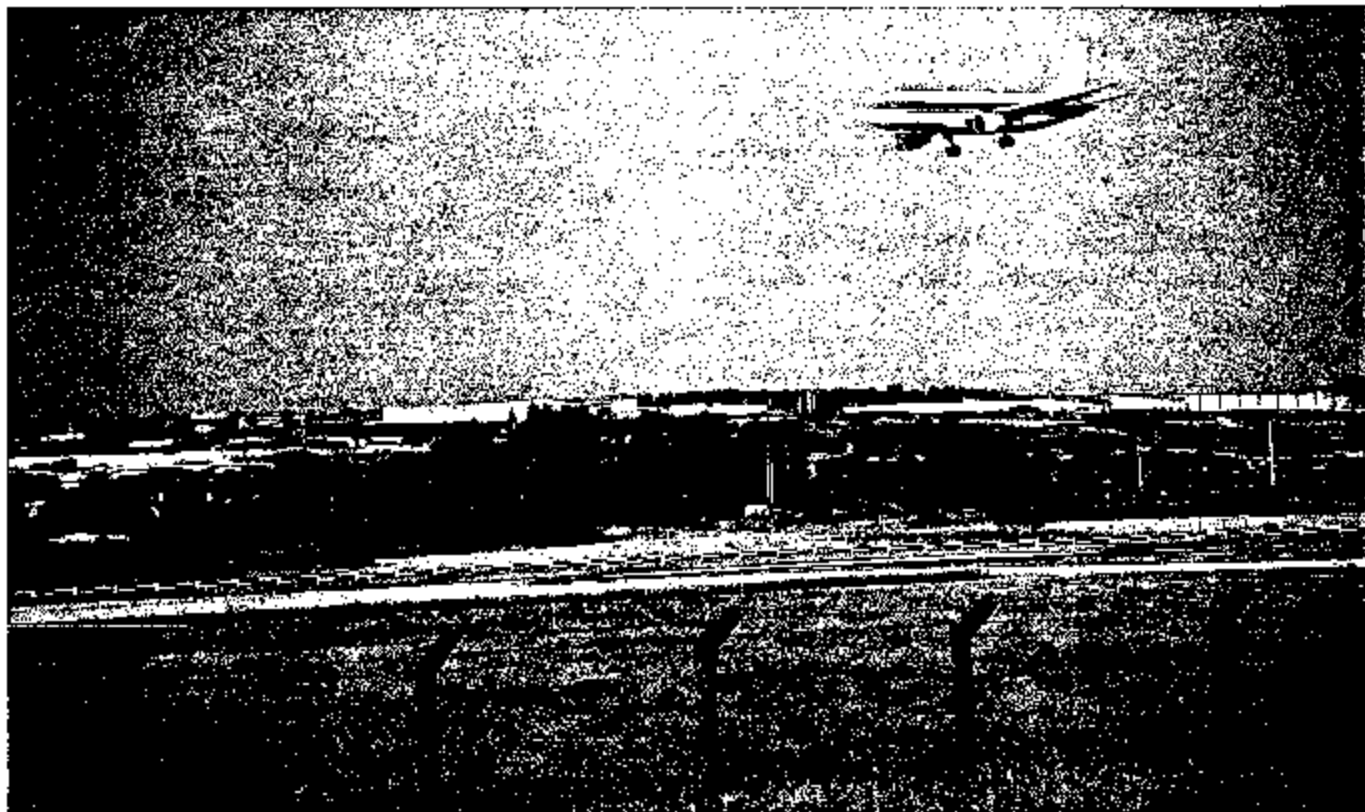
Ash disposal. Fly ash is a fine, sand-like residue that is caused by incomplete burning of organic fuel. "Fly ash from resource recovery facilities that are fired by municipal solid waste, coal or wood," the AC said, "is generally considered not to be a wildlife attractant because it contains no putrescible matter. FAA generally does not consider landfills accepting only fly ash to be wildlife attractants ..."

Construction and demolition (C&D) debris landfills. The AC said, "FAA generally does not consider C&D landfills to be hazardous wildlife attractants, if those landfills are maintained in an orderly manner; admit no putrescible waste of any kind; and are not co-located with other disposal operations."

Water detention or retention ponds. Providing for the runoff of storm water from runways, taxiways and aprons is a normal and necessary function at airports. Detention ponds hold storm water for short periods, and retention ponds retain water indefinitely. "Retention ponds are more attractive to hazardous wildlife than detention ponds because they provide a more reliable source of water," the AC said.

"To facilitate hazardous wildlife control, FAA recommends using steep-sided, narrow, linearly shaped, rip-rap [large broken stones]-lined water detention basins rather than retention basins. When possible, these ponds should be placed away from aircraft movement areas to minimize aircraft-wildlife interactions. All [surrounding] vegetation ... that provides food or cover for hazardous wildlife should be eliminated."

"If soil conditions and other requirements allow, FAA encourages the use of underground storm water infiltration systems ... because they are less attractive to wildlife."



Hazardous wildlife may be drawn to the airport environment by natural habitat, such as the wooded area adjacent to this runway. (Photo: © 1997 PhotoDisc Inc.)

Landscaping. "FAA recommends that airport operators approach landscaping with caution and confine it to airport areas not associated with aircraft movement," the AC said. "All landscaping plans should be reviewed by a [WDMB]. Landscaped areas should be monitored on a continuing basis for the presence of hazardous wildlife. If hazardous wildlife is detected, corrective actions should be taken immediately."

Golf courses. The open space provided by a golf course aids in noise prevention and can be used for emergency landing. An on-airport golf course may also be a revenue source for the airport. Nevertheless, the large grassy areas and open water found on most golf courses attract waterfowl. The AC said, "Because waterfowl and gulls occur throughout the [United States], FAA recommends that airport operators exercise caution and consult with a [WDMB] when considering proposals for [golf] course construction or expansion on or near airports."

Agricultural crops. The AC generally did not object to agricultural crop production on airports when the agricultural operation is closely monitored by the airport operator or sponsor to ensure compliance with guidelines. The AC said:

1. "FAA recommends that no agricultural activities be conducted in the runway safety area (RSA), OFA and the OFZ ..."

2. "Restricting agricultural operations to areas outside the RSA, OFA, OFZ and runway visibility zone (RVZ) will normally provide the minimum object clearances required by FAA's airport design standards. FAA recommends that farming operations not be permitted within areas critical to the proper operation of localizers, glideslope indicators or other visual or electronic navigational aids ... If navigational aids are present, farm leases for on-airport agricultural activities should be coordinated with IAA's Airway Facilities Division."²
3. "The OFA normally extends the farthest [into approach areas] and is usually the controlling surface ... However, for some runways, the TSS may be more controlling than the OFA.¹ The TSS may not be penetrated by any object."
4. "IAA recommends that no agricultural activities be permitted within the RVZ. If the terrain is sufficiently below the runway elevation, some types of crops or equipment may be acceptable ..."
5. "Farming activities should not be permitted within a taxiway's OFA. The outer portions of aprons are frequently used as a taxi lane ... Farming operations should not be permitted between runways or parallel taxiways."

6. "If a problem with hazardous wildlife develops, FAA recommends that a professional ... [WDMB] be contacted and an on-site inspection be conducted. The ... [WDMB] should be requested to determine the source of the hazardous wildlife attraction and suggest remedial action."

The AC included a detailed table showing the minimum distances between certain airport features and any on-airport agricultural crops.

"Whenever on-airport operations are stopped due to wildlife hazards or annual harvest, FAA recommends plowing under all crop residue and harrowing the surface smooth," the AC said. "This will reduce or eliminate the area's attractiveness to foraging wildlife. FAA recommends that this requirement be written into all on-airport farm use contracts and clearly understood by the lessee."

The AC described procedures by which airport developers, land developers and owners in the United States should notify the FAA about "known or reasonably foreseeable" practices in or near airports that attract, or could attract, wildlife. In addition, the AC said, "If an existing land use practice creates a wildlife hazard, and the land use practice cannot be immediately eliminated, the airport operator should issue a Notice to Airmen (NOTAM) and encourage the land owner or manager to take steps to control the wildlife hazard and minimize further attraction."♦

Editorial note: This article was adapted from U.S. Federal Aviation Administration Advisory Circular (AC)

150/5200-33, *Hazardous Wildlife Attractants on or near Airports*, May 1, 1997.

References

1. FAA Advisory Circular (AC) 150/5300-7, *Airport Design*, Nov. 10, 1994.
2. FAA Order 6750.16, *Siting Criteria for Instrument Landing Systems*, Oct. 31, 1995.

Further Reading from FSF Publications

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AIRPORT OPERATIONS

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Staff: Roger Rozella, director of publications; Rick Darby, senior editor; Douglas Greenwood, senior editor; Todd Lofton, editorial consultant; Karen K. Ehrlich, production coordinator; Ann L. Mulliken, assistant production coordinator; and David A. Grzelocki, librarian. Jerry Lederer Aviation Safety Library.

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APPENDIX 32

The Potential for financial loss resulting from aircraft bird strikes



The Potential for financial loss
resulting from aircraft bird strikes

by M. Robinson

Aon Group Limited, Aviation

AON *Aon Group Limited*

Prepared for Bird Strike Committee Canada #27 (in absentia)

Ottawa – November 1997

"I used ... to keep a book in which I would talk to myself. One of the aphorisms I wrote was, 'The structure of a play is always the story of how the birds came home to roost ...'".

A. Miller – Harper's Magazine Aug. 1958

Following an introduction, this paper contains a brief study outlining some arguments concerning the perceived need for maintaining an adequate bird dispersal programme complemented by an adequate "airport and/or air traffic control legal liability" insurance programme. It includes reference to known losses caused by strikes and an analysis suggesting that in an increasingly litigious world, bird dispersal measures must be vigilantly maintained. Additionally, it addresses the increasingly posed question of the overall costs, to airlines, of bird strikes.

Introduction:

This study outlines our strong belief as to why there is a need, perhaps an increasing need, for airport and air traffic control authorities to maintain comprehensive wildlife control and/or dispersal programmes and the greatest wildlife hazard to arrange the appropriate legal liability insurance covers. Since it is aircraft bird strikes that arguably present aircraft, our comments are focused on this subject. Whilst the thrust of this review concentrates on the problem of aircraft bird strikes, it is not just birds that may cause problems; mammals such as deer can cause damage to aircraft, as indeed, can even smaller mammals (perimeter fences must be well maintained). Animals such as rabbits, mice and voles form significant populations which may well attract the attentions of various raptors and carnivorous mammals. Nevertheless, it is arguably the potential problems associated with birds at and around an airport that must most exercise the minds of those responsible for wildlife control management.

We commence our study by considering the potential for loss i.e. may an airport and/or air traffic control authority be found legally liable in the event of:

- ◆ loss of, or damage to an aircraft
- ◆ injury or death of passengers and damage to their property, or
- ◆ third party injury, death or property damage

resulting from an aircraft bird strike.

We offer a brief review of:

some known losses

of potential exposures i.e. fleet composition, traffic development etc.- both current and forecast, and general aviation;

some potential loss scenarios etc.

We feel confident our study will offer "food for thought"; adequate bird control and/or dispersal measures and airport and/or air traffic control legal liability insurance are vital. In general terms, airport legal liability insurance is not expensive and considerable insurance capacity is available; limits of circa US\$1,000 million and above are fairly simply arranged, subject always to satisfactory individual risk profiles. Failure to maintain a comprehensive and successful wildlife control programme could result in loss of life resulting from an aircraft accident and an airport and/or air traffic control authority facing significant compensation claims.

An accident involving a Boeing 747 aircraft could result in over 500 passenger fatalities - is this so impossible? We must always remember that the only difference between the possible and the impossible is that the impossible is merely likely to happen less often! Financial compensation

demands, for the aircraft hull, passenger fatalities and any third party injuries and/or damage following an aircraft bird strike could be significant.

Complacency is the enemy of safety! There is a need for constant vigilance on the part of those responsible for bird control and/or dispersal at airports; the airport and/or air traffic control authority must be considered as the first line of defence. Successful bird control etc. programmes will be subject to a number of management factors. These might include an analysis of the overall situation to perhaps incorporate a detailed study of bird populations and their behaviour, a survey of the airport environment and a review of existing control measures. Having considered the foregoing, the authority should be in a position to evaluate any actual bird hazard problem, install bird dispersal devices such as pyrotechnic devices, distress call simulators etc. and consider environmental responses such as land management i.e. care of land surrounding the airport. This might include grass management, removal of trees and bushes, drainage of wet areas etc. The individual authority should maintain a specialist unit to deal with the bird hazard problem; this unit will work closely with both the authority and aircraft operators and liaise on awareness programmes directed at involving local authority's within the vicinity of the airport. Control measures must be subject to regular examination, there should be a rolling examination of staff training, staff motivation etc. since this must be an evolving process. All in all, each individual programme should take account of the specific characteristics of the airport to ensure that all reasonable risk management measures are both identified and in situ.

One particularly interesting question relates to regional and/or commuter airline activity. The regional and/or commuter airline is probably neither less, nor more likely, to encounter the aircraft bird strike problem. Indeed, the number of reported accidents is quite small. Nevertheless, ever increasing pressures on the commuter and/or regional airline community might find them forced to use some of the smaller airports where resources for wildlife control might be limited? It would be interesting to hear the views of both aircraft and airport operators on this subject.

We suggest the arguments for both maintaining comprehensive wildlife control programmes and buying adequate airport and/or air traffic control legal liability insurance will be found compelling. Surely no further persuasion will be required?

October, 1997

*The potential for an airport and/or air traffic control legal liability
loss resulting from an aircraft bird strike and some observations
apropos aircraft bird strike costs:*

We begin by asking three simple questions, namely,

- is the potential for loss real?
- do losses occur?
- can an airport and/or air traffic control authority be found legally liable following an accident?

We answer in the simplest of terms, yes, yes and yes. The potential for loss is real, (many) accidents have occurred and an airport or air traffic control authority can be found legally liable following an accident. It is not just the daily regimen of slips and falls, collisions with glass doors etc. within an airport terminal that require an authority to purchase adequate airport legal liability insurance cover. The ever present possibility of debris on the runway, birds etc. with consequent threat to air traffic will always be a constant cause for concern and require vigilance in maintaining avoidance measures.

The trend for ever increasing legal liability damages awards must always be borne in mind. International protocols regarding passenger legal liability award levels are currently under review; could any such review impact adversely on an authority? I understand that according to Japanese philosophy, recourse to litigation represents a fundamental failure in human relations; we in the United Kingdom are currently witnessing an explosion in the desire to seek legal remedies - everything now seems to have a monetary price as we seek the new Holy Grail, compensation. It has been observed that once the law starts talking, there is no stopping them. Oddly enough, even in these troubled times, some airports, including some of the larger ones, appear to purchase minimum levels of cover. Surely a false economy?

Minor damage to aircraft caused by bird strikes may perhaps be caused, but the total destruction of an aircraft with resultant passenger fatalities is surely something of a long shot? Nevertheless, it is a possibility, and perhaps an increasing possibility?

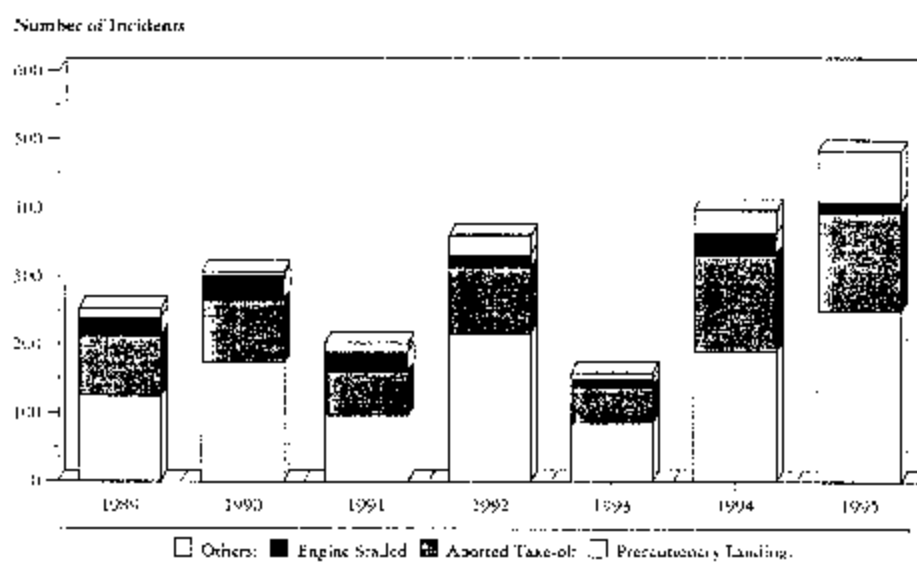
In response to the question as to whether an airport and/or air traffic control authority might be found legally liable following a bird strike accident, the answer is an emphatic yes. I am able to cite two such incidents.

ii) the successful action by Safeco Insurance Company against the City of Watertown (in the United States), following a June, 1975 loss, caused by an aircraft bird strike (gulls), of a Sabreliner aircraft. I understand that the court held "...that the proximate cause of the crash was the failure to warn the pilot of the presence of birds..." Judgement for the full value of the destroyed aircraft was entered against the airport operator.

iii) the successful action taken against Norwich Airport (in the United Kingdom) following a December, 1973 loss, caused by an aircraft bird strike (again, gulls), of a Falcon 20 aircraft. The Judge, in his summing up, noted that "...the Defendants owed the Plaintiffs (the aircraft operator) the common duty of care, that is, a duty to take such care when carrying on their activities at the airport as was reasonable in the circumstances...". After weighing up all the considerable amount of evidence, the Judge decided that the Defendants failed in their duty and that "...there must be judgement for the Plaintiffs for damages..."

The fact that both incidents occurred during the 1970's provides no cause for complacency; the (November, 1996) Bird Strike Committee Canada meeting #25 heard that Air France were seeking legal redress against JFK (New York) as a result of a multiple Canada Goose strike in 1995, by an Air France Concorde aircraft. Like Topsy, the numbers of Canada Geese just seem to grow and grow; for the United States alone, a reported 1966 population of circa 1 million had risen to circa 10 million by 1994 with numbers still rising!

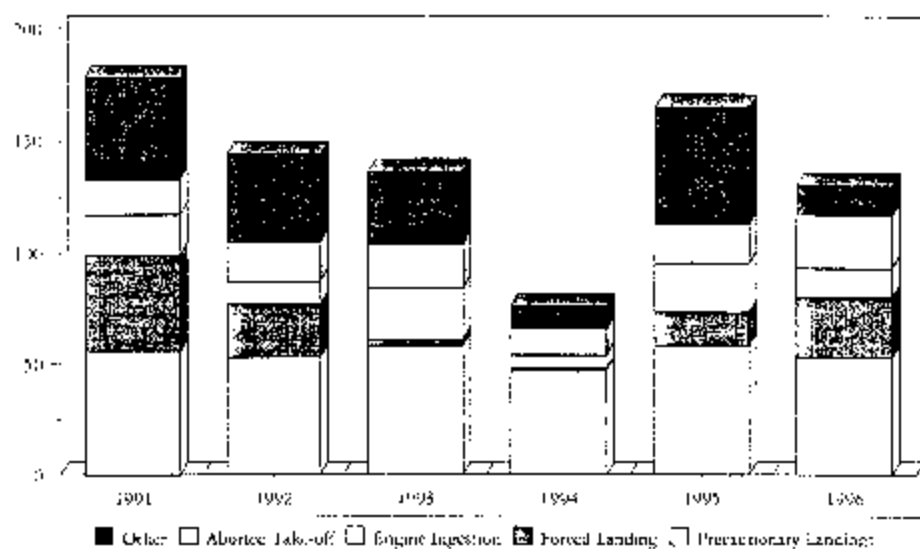
Are aircraft bird strikes a rare occurrence? The following chart, based on ICAO supplied information (from less than 50 countries) covering the period 1989 to 1995 inclusive, identifies the consequences of bird strikes by individual effect, quite clearly demonstrating that an airport and/or air traffic control authority must constantly monitor bird populations and take the appropriate measures to disperse flocks. It will be noted that the number of incidents appears to be increasing, or is it that the number of reported incidents has increased?



If we view the above in tabular form, we note the following breakdown.

Year	Prec. Landing incidents	Aborted t/o incidents	Engine s/d incidents	Other incidents	Total reported incidents
1989	125	88	26	14	253
1990	173	91	36	7	307
1991	97	63	28	14	202
1992	216	97	17	29	359
1993	86	53	9	11	159
1994	189	142	31	34	396
1995	249	142	16	74	481
Totals	1,135	676	163	183	2,157

The following illustration identifies the Canadian experience, based on published Transport Canada figures:



During 1997, we have seen press reports relating to, (i) an Air Foyle An-124 aircraft returned to Genoa Airport (Italy) following a bird strike (around fifty gulls) resulting in multiple engine damage and (ii) a QANTAS Boeing 737 aircraft returned to Sydney following a bird strike (a single bird - an Ibis?).

As to actual losses, the following table identifies some individual aircraft total losses, resulting from aircraft bird strike(s):

Loss date:	Location:	Aircraft type:	Bird species:	Fatalities:
Oct., 1960	Boston, USA	L 188 Electra	Starlings	62 fatalities
Nov., 1962	Maryland, USA	Vickers Viscount	Whistling Swan	17 fatalities
March, 1973	Atlanta, USA	Lear 24	Cowbirds	7 fatalities
Nov., 1975	JFK, New York	DC-10	Gulls (various)	none known
April, 1978	Gosselies, Belgium	Boeing 737	Wood Pigeon	none known
July, 1978	Kalamazoo, USA	Convair 580	Scarrowhawk	none known
Sept., 1986	Madras, India	Airbus A300	Black Kite	none known
Sept., 1988	Bahar Dar, Ethiopia	Boeing 737	Sneckled Pigeons	35 fatalities
Dec., 1991	Maasi-Mara, Kenya	Piper PA31	White Headed Vulture	9 fatalities
Jan., 1992	Maasi-Mara, Kenya	Cessna 401	Marabou Stork (?)	7 fatalities
Jan., 1995	de Bourges, France	Falcon 20	Lapwings	10 fatalities
Sept., 1995	Elmendorf, USA	"AWACS"	Canada Geese	24 fatalities
Oct., 1995	Addis Ababa, Ethiopia	Twin Otter	White Backed Vulture	none known
July, 1996	Eindhoven, Holland	Hercules	Starlings/Lapwings	34 fatalities
July, 1996	Aktion, Greece	"AWACS"	a large black bird?	none known

And - what of the culprits? Is the threat increasing or diminishing? In very broad terms, I understand the threat must be perceived as increasing. Airline fleet development forecasts suggest some significant increases in aircraft numbers as we move into the next century; please refer to the comments included later in this study. Whilst it is difficult to provide an accurate measure of bird populations, I would appear that in general terms, numbers of gulls, geese, (mute) swans and other wildfowl are either stable or showing increases (witness the United States' Canada goose population explosion).

Might global warming have an affect on bird populations, habits etc.? A contentious subject perhaps and any consequences may not make themselves felt until some time in the future, although one change that has already been noted here in the United Kingdom, according to the British Trust for Ornithology and doubtless elsewhere, is that birds are now nesting earlier. Might changing weather patterns affect migratory activity? Notwithstanding, it is fair to say that the jury is still very much out on the impact of global warming, both on the climate and wildlife. Indeed, it is perhaps premature to attribute changes in bird behaviour to global warming, since there are number of other factors affecting bird numbers and behaviour, including changes in agricultural practices etc.

Perhaps I might close this section with a few observations on the so-called, "hidden costs" of aircraft bird strikes. These costs are gaining an increasingly prominent profile. How much worldwide aircraft bird strikes cost the airlines annually? I have heard a figure of circa US\$2 billion mentioned although I am inclined to think that this might be a gross underestimation! How are these costs calculated? Firstly, physical damage to the aircraft. Secondly, the "hidden costs". In the event of an aircraft accident/incident, the aircraft operator will be saddled with a number of unexpected costs; many are not recoverable under the standard insurance policy and are referred to herein as "hidden costs". They will generally be paid by the aircraft operator. These may perhaps occur following a precautionary landing (such as a return to airport), an aborted take off or an engine (single or multiple) shutdown. The extent of such "hidden costs" is determined by a number of factors which include:

- the level of aircraft damage

- the operator involved (ie. fleet size)

- type of operation (passenger or cargo)

- proximity of aircraft involved to the repair facility.

As to the factors contributing to these so-called, "hidden costs", they might include:

- the cost of re-routing passengers - this might include the cost of complementary tickets issued to disadvantaged passengers to make up for any inconvenience*

- the cost of passenger and/or crew accommodation, refreshments etc. ie. in the event of a delay in excess of circa 12 hours, all on-board food has to be replaced*

- costs incurred to replace dumped fuel*

- costs incurred in bringing in replacement aircraft and/or engines (these are dependant on aircraft availability)*

- contractual penalties ie. for late delivery of freight/cargo/mail*

- any inspection costs*

- additional maintenance costs*

additional airport and/or air traffic control charges (including storage charges); relocation of crews, cost of replacement crews

for seasonal operators the timing of the incident is important

loss of confidence and perceived damage to the "good name" of the airline i.e. resulting in cancellations, loss of revenue and extra expenses incurred to restore the airline's "good name" etc.

the "ripple" effect of any of the foregoing which may include loss of revenues.

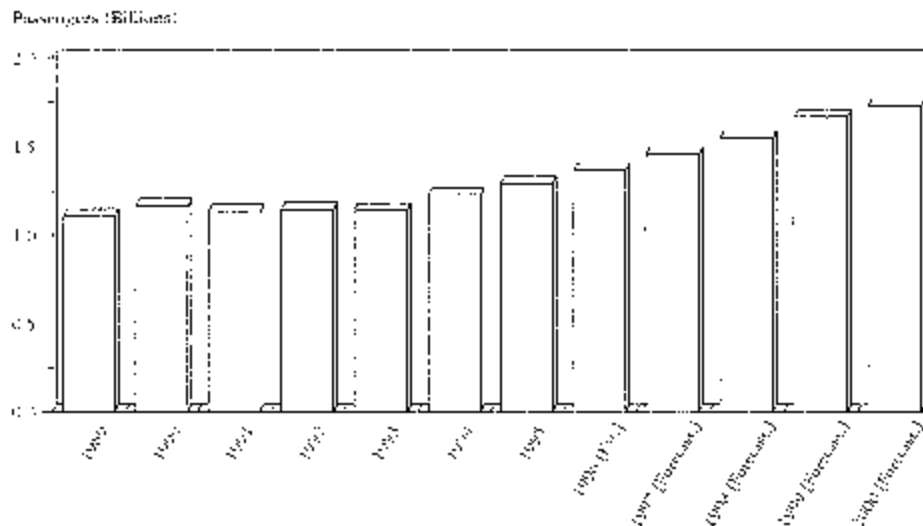
A number of studies have been, are being undertaken, in an attempt to quantify cost levels, it would however be rash to offer any definitive figures bearing in mind the wide diversity of operations and geographical area's of operation etc.

With regard to the previously mentioned 1997 Air Foyle incident, press reports indicate that " it cost in excess of US\$10 Million to repair the damage and to fly in both a Boeing 747 freighter and an An-22F aircraft to reposition the (An-124's) cargo to Milan..."

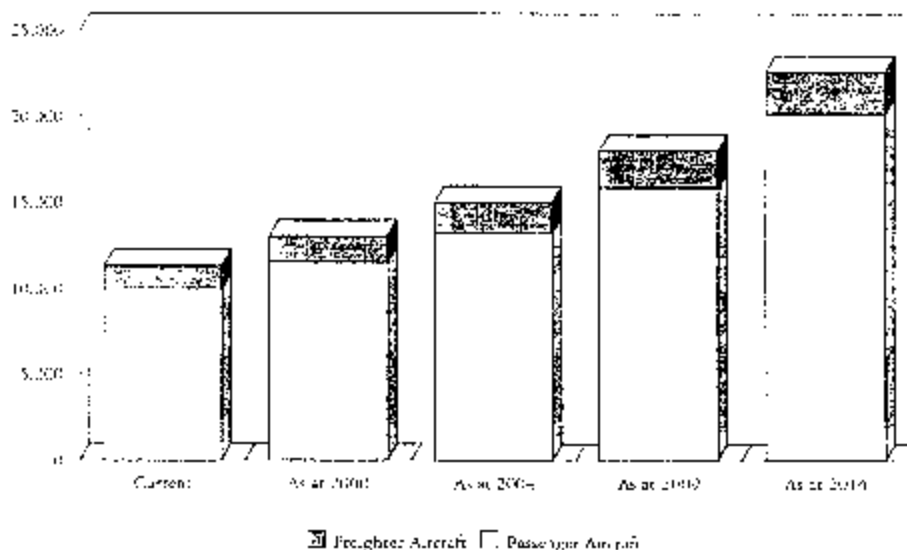
Nevertheless, I am increasingly inclined to the view that since it is probably (perhaps I should say, almost certainly) these "indirect costs" which hurt the aircraft operator most (although does out of sight equal out of mind?) that they might eventually be used as a spur by the aircraft operator to pressure airports into ensuring comprehensive and successful wildlife control measures are maintained? Notwithstanding, this is probably far too simplistic a view?

A brief review of exposure levels - both current and forecast:

It is commercial air traffic and the carriage of passengers that presents the greatest potential for major legal liability exposure. Passenger traffic levels are ever increasing; if might perhaps commence with the global view, ICAO confirm a continued annual rise in both scheduled passengers and freight tonnes carried (both actual and/or projected). Passenger enplanement activity and/or forecasts is as reflected within the following chart:

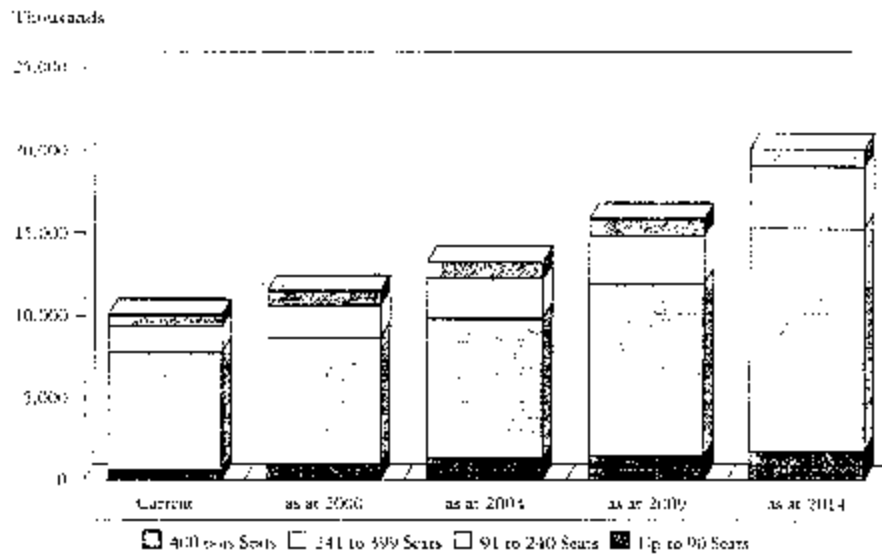


To accommodate the forecast increases in traffic levels, some significant fleet development programmes are anticipated; current industry based indications suggest that the world jet aircraft fleet (excluding eastern built aircraft) will probably more than double within the next twenty years. The following chart, based on published estimates, offers my interpretation of world fleet development forecasts (including a general split between dedicated passenger and freighter aircraft). Of course, to bring these forecasts to fruition will require some considerable financial investment; according to published estimates, this could amount to excess of circa US\$50 billion annually, by the year 2004 and beyond?

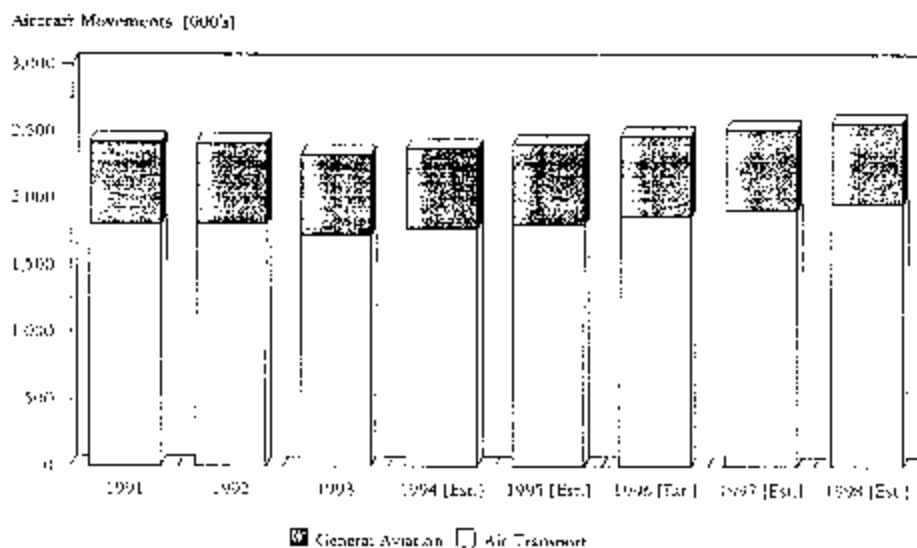


As noted above, it would appear that at any one time, approximately 15% of the fleet will be dedicated cargo aircraft.

The following chart excludes these aircraft and offers a very general indication of the current and/or projected passenger aircraft fleet by seating band:



Turning our attention to specific Canadian activity, the following charts identify historic and forecast traffic levels, both aircraft and passenger movements, at the major 30 Canada airports (as defined by Transport Canada), based on Transport Canada promulgated figures. All projections point upwards:



Another factor by which we may determine potential for loss is to consider individual aircraft cycles. Based on published material, we understand that the Canadian registered airline fleet currently operates annually circa 1,600 cycles per passenger aircraft and around 825 cycles per freighter aircraft; with daily utilisation standing at almost 5 hours per passenger aircraft and 1 hour per freighter aircraft.

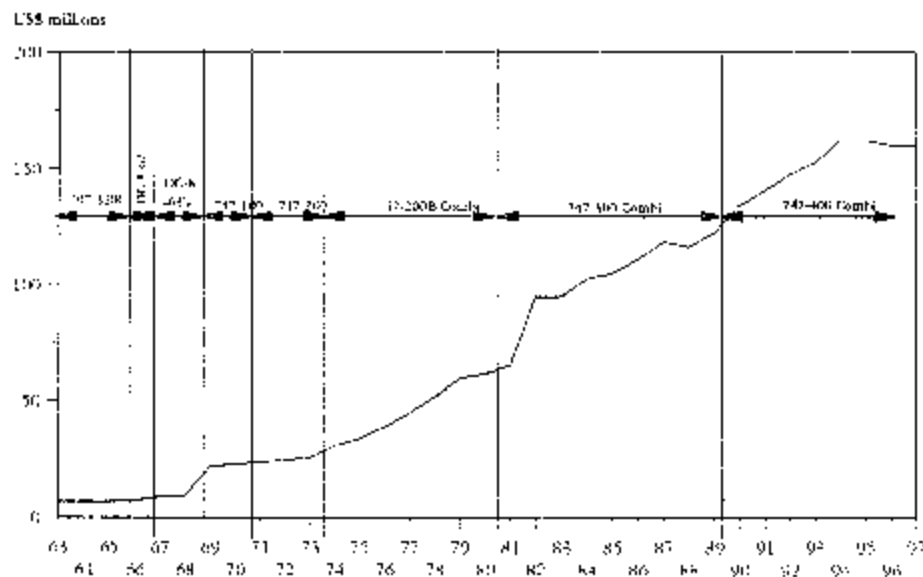
Having considered commercial aircraft activity/distributions etc. we should perhaps briefly touch on "general aviation" (there are many definitions of "general aviation" - our very simple interpretation is ... *aerial observation, agricultural, air taxi (this seems to cheerfully hover between both the commercial and "general aviation" camps dependant on whose definition is under review), corporate/executive, private/recreation and instructional activity* ... Whilst the potential for major legal liability loss is of course much less than for commercial activity, it is sensible to offer our understanding of Canadian "general aviation" activity. I understand that there are currently circa 22,000 active "general aviation" aircraft in Canada; operating for approaching a million hours annually.

Increases in aircraft numbers (particularly the number of operational wide body aircraft) and increases in traffic levels are met head on by increases in certain bird population levels - could this combination of circumstances result in an increase in accidents?

The potential for financial loss – is the sky the limit?

It is of course, the airline fleet composition that is of particular importance when considering airport and/or air traffic control legal liability insurance and the possibility of a major accident involving aircraft. We specifically identify two factors, namely (i) aircraft values and (ii) individual aircraft seating capacities.

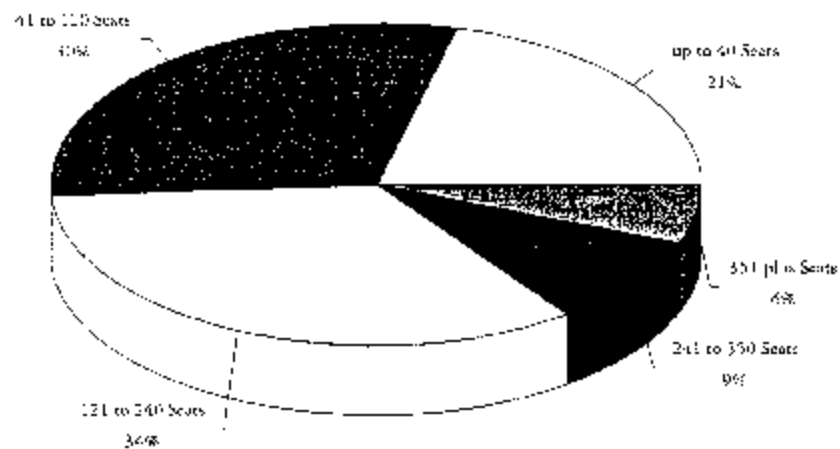
Firstly, let us consider individual aircraft values. The following chart, showing highest basic list prices, reflects the inexorable rise in aircraft values since 1963 (actual insured values are often considerably in excess of list prices once lease considerations etc. are taken into account - aircraft valued at excess of US\$ 200 million plus are currently being operated by the world's airlines):



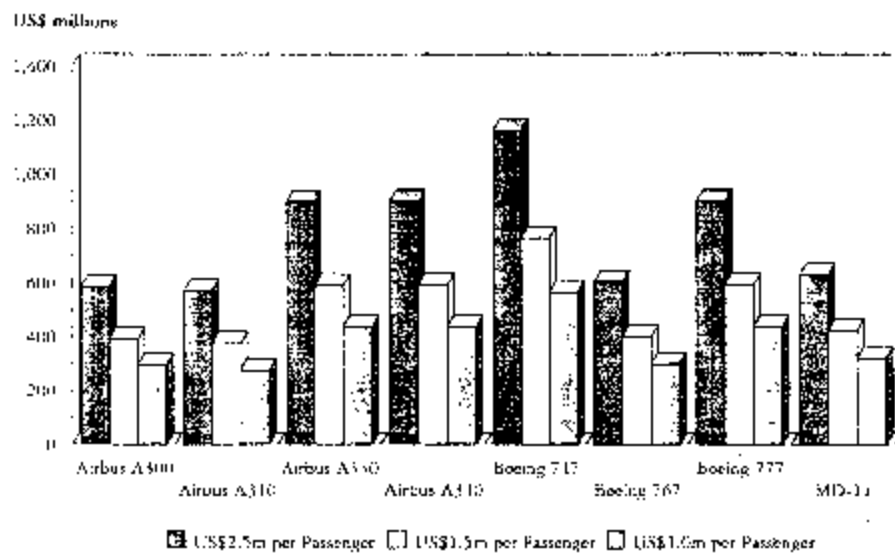
These increasing values are reflected within the overall airline fleet "insured value". Since 1986, the overall fleet value has increased by an extraordinary 200% (plus)! Our researches indicate that there are currently excess of 1,000 aircraft valued at US\$100 million and over, either in operational service, or on order to airlines.

However, whilst aircraft insured values are a very important subject for consideration, it is the potential for resultant legal liability loss in the event of airline passenger injury and/or fatality which provides the major cause for concern. What of aircraft passenger seating capacities? The following chart offers a general understanding of the individual aircraft seating capacity breakdown for the current world airline jet/turbo prop fleet (excluding business jet and former Soviet Union built aircraft). It will be noted that approximately 6% of the world fleet of circa 17,000 aircraft are fitted with 350 (plus) seats, this represents 9% of the airline jet fleet. Industry forecasts expect this figure will be considerably increased by the years 2014/15; perhaps to 20% or upwards i.e. circa 4,000 plus aircraft.

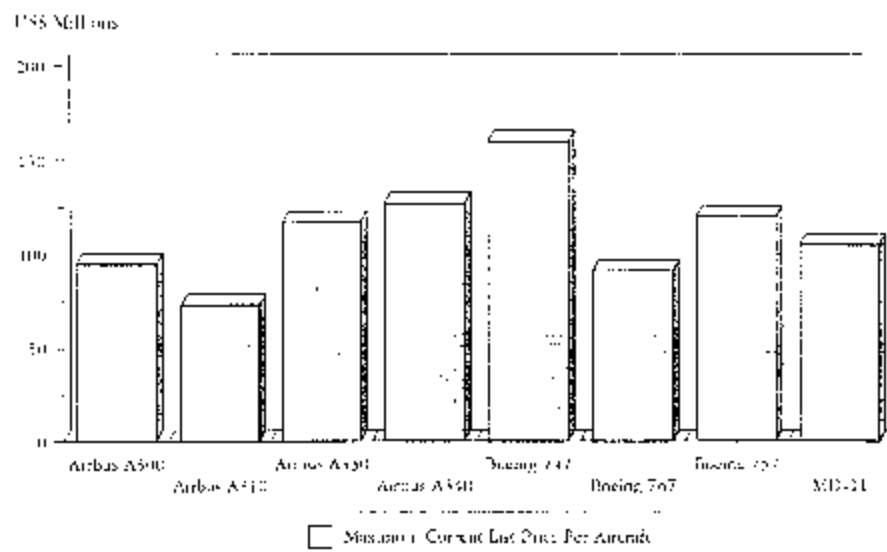
We have mentioned the possibility of significant compensation claims. This is not an exaggeration. As mentioned earlier, aircraft valued at US\$200 million plus are currently being operated by the world's airlines. However, whilst aircraft insured values are an important subject for consideration, it is the potential for resultant legal liability actions in the event of airline passenger injuries and/or fatalities which provide the major cause for concern, whether against an individual airline, airport, air traffic control authority, or whoever might be deemed to bear a responsibility for the accident.



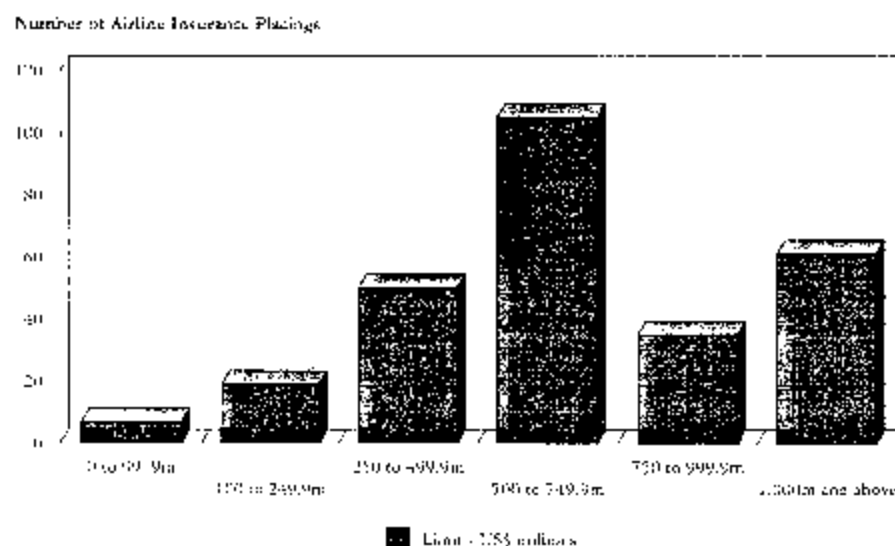
Perhaps we should now consider some possible "compensation scenario profiles". The following chart, presented perhaps as a scare tactic as much as anything else, identifies various potential cumulative compensation claims for some of the current major operational aircraft types. Such potential claims, based on an aircraft total loss and assuming a 70% passenger load factor, are calculated by taking the basic aircraft list price plus selected (across the board) passenger award levels, although they exclude any third party injury or property damage compensation award projections:



Unfortunately, it does not require passenger fatalities to result in a significant claim. We have already considered the inexorable rise in aircraft values; the following chart identifies the maximum list price for the various current major (western built) high valued production jet aircraft:



Finally, and by way of closing these brief comments, I suggest that for a major international airline, a legal liability insurance policy limit of US\$1,250 million may now be considered a minimum requirement; by the end of 1997 this figure might well have risen to US\$1,500 million! A perhaps controversial point but it is interesting to consider whether an airline might (be able) to insist on individual airport and/or air traffic control authorities carrying a specified minimum level of insurance prior to the airline using the airport? The following chart identifies the 1996 insurance policy selected legal liability limit for excess of 350 of the world's major airlines (some group airline insurance arrangements include a significant number of major airlines):



Conclusion, or perhaps more simply ... Goose - Please Vamoose!™:

To summarise my earlier observations:

- ◆ Individual insured aircraft values now exceed US\$ 200 million!
- ◆ The wide body aircraft content of the world airline fleet is ever increasing.
- ◆ In general terms, bird populations (and particularly Canada geese) are increasing;
- ◆ Changing weather patterns might result in changes to migratory patterns - bird dispersal strategies must be constantly reviewed;
- ◆ There is an increasing trend to seek legal remedies to compensate any and all misfortunes - international passenger legal liability protocols are under review - passenger legal liability awards are generally increasing - will courts be increasingly sympathetic to the plaintiff?

On the evidence presented, I am sure that you will agree that the case for the maintenance of adequate airport bird dispersal techniques and airport and/or air traffic control legal liability insurance is compelling; I very much hope that my arguments have been persuasive.

Whilst the possibility of a major loss may be slight, it is nevertheless real and must be kept in mind. Henry Kissinger suggested that *"...the real distinction is between those who adapt their purposes to reality and those who seek to mould reality to their purposes..."*. There is always a need to both accept and adapt to, the current reality!

Thank you

APPENDIX 33

The Brazilian Bird Strike Reduction Program



THE BRAZILIAN BIRD STRIKE REDUCTION PROGRAM

by

José Pompeu Brasil

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Centro de Investigação e Prevenção de Acidentes Aeronáuticos - CENIPA
(the Brazilian Aviation Safety Center)**

AVIATION SAFETY: CONFRONTING THE FUTURE

50th annual International Air safety Seminar of Flight Safety Foundation

27th International Conference of Federation of Airworthiness

International Air Transport Association

Washington, D.C. - November 6, 1997

Abstract

Hundreds of ingestion events occur each year on airports in Brazil, and many of them are likely to cause engine failures, engine damage, aborted takeoffs, turnbacks and diversions. This is not a new problem to the aerospace industry, being something very similar to what happens in New York or Israel. What makes it special is the bird category – *Coragypus Atratus* – which weight ranges from 3 to 5 lb., and its population (we recently counted 1.8 birds per square meter in a damp near Rio de Janeiro International Airport,).

This paper presents the Brazilian problem's peculiarities (birds, its population and location – most of the counties garbage dump sites are close to the airports), but especially describes the actions being taken in order to reduce the frequency of such incidents: Organization of the Brazilian Bird Strike Information System; creation of the National Bird Strike Committee; Seminars held on each of the most affected airports, where the problems are presented and solutions are discussed and proposed by all segments involved; wide media coverage, in order to expose the problem to the public and stimulate it to ask for answers from the involved segments; test of gas-cannons in certain airports; and even a very innovative performance of a group of children, aiming to stimulate society participation in the process.

Introduction

The bird population growth around the world, caused by the increased ecological consciousness and combined with the expansion of the air transport in most of the countries are resulting in a preoccupying increase of the bird strike statistics.

The problem affects a great majority of countries, assuming different characteristics for each peculiar geographic region. The presence of Gulls and Geese in the vicinity of airports has caused accidents in the United States. The main reason is the similarity between the airports' environment and the birds original habitat, making it their choice for rest on their long migration trips from North to South and vice-versa. Israel, on the other hand, albeit its diminutive territorial dimensions, is situated exactly on the route of 500 million migration birds flying between the Eurasian continent and Africa¹. The result is extremely crowded airspace for fighters and birds.

In Brazil, probably the most diversified bird population region of the world, with more than 1,700 known species, we almost never have reports of bird strikes with migratory birds. However, due to some very specific problems that we intend to discuss later, our statistics are still very alarming, and an aggressive Bird Strike Reduction Program is needed.

Our goal is to present the peculiarities of our problems and the unique countermeasures being developed to reduce the risk of accidents due to bird and aircraft collision.

2. History

Brazil has a well established flight safety structure. Created in 1971, we have almost 3,800 flight safety specialists who are trained at the Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA), our aviation safety center for military and civil aviation. Working in large airlines, small aviation companies, aeronautical constructors, technical centers, airport administrations, military units and commands, traffic control system and aeronautical schools, we form a large systemic structure – SIPAER² – connecting all elements directly to the safety center in Brasília.

Our database, computerized since 1981 holds all accidents and incidents that have happened in Brazil since then. It controls not only all investigations and corrective action implementation, but also produces statistics information and trend analysis studies.

¹ SHAMOUN-BARANES, Judy. Presentation at the 7th Annual Meeting of the Bird Strike Committee - USA 1997, Boston, MA.

² Sistema de Investigação e Prevenção de Acidentes Aeronáuticos (Aeronautical Accident Investigation and Prevention System).

However, it was only in 1991 that we started developing a Bird Strike Reduction Program. The accidents and incidents related to bird collisions, even though already registered in our database, started to be inserted in a separated system, with specially designed fields like type of bird, collision altitude, aircraft speed, etc.

To feed it, we developed two information sheets that were disseminated throughout the SIPAER system. The first one contains the collision information available immediately after the occurrence, and the second one contains information that is available later, like aircraft repair costs. They are very simplified forms of only one page that can be sent to us by mail or fax.

In order to identify the bird species from its remains collected after collisions against aircraft, we signed a cooperation contract with the Brazilian organization responsible for wild birds conservation (CEMAVE³), which is subordinated to the Ministry of the Environment. They are able to identify quickly and reliably most of the remains we send to them, including DNA identification, if needed, at no cost.

At this point, we had a database system, a reasonable communication system and specialists (biologists) to identify the remains of birds. We then needed to disseminate all we could about it to the aeronautical industry and wait a few years in order to start retrieving statistical information to help us develop actions to prevent similar events.

3. Risk Analysis

When analyzing Risk⁴ for the Bird Strike problem, we have to correlate the **probability** of such accident to happen, the amount of **exposure** to that risk and the **severity** of its consequences.

Analyzing the component "severity" of an accident caused by bird strike, we must first consider two aspects: aircraft speed and bird size and weight (density).

The formula:

$$E = \frac{m \cdot v^2}{s}$$

("E" = energy transferred in impact "m" = mass "v" = speed "s" = impact area)

used for a simplified calculation of the energy transferred on a bird strike, eliminates the need for explanations about the importance of the aircraft speed. Such importance

³ Centro de Pesquisas para a Conservação das Aves Silvestres (Wild Birds Conservation Research Center).

⁴ Risk Management is a systematic process initially developed by Bell helicopters and now used by aviation safety organizations, mostly in the military, in order to reduce accidents by eliminating, reducing or accepting but recognizing the risk of missions before they are performed.

is increased when the impact happens against the engine blades, since the speed for calculations is the resultant between the aircraft and the engine rotational speed⁵. Add to this the fact that about 35% of bird strikes occur against engines⁶ (see figure 1), and we can get to the probable severity of the accident: Loss of power, resulting in hull loss and even deaths. (Severity decreases for conventional powered aircraft.)

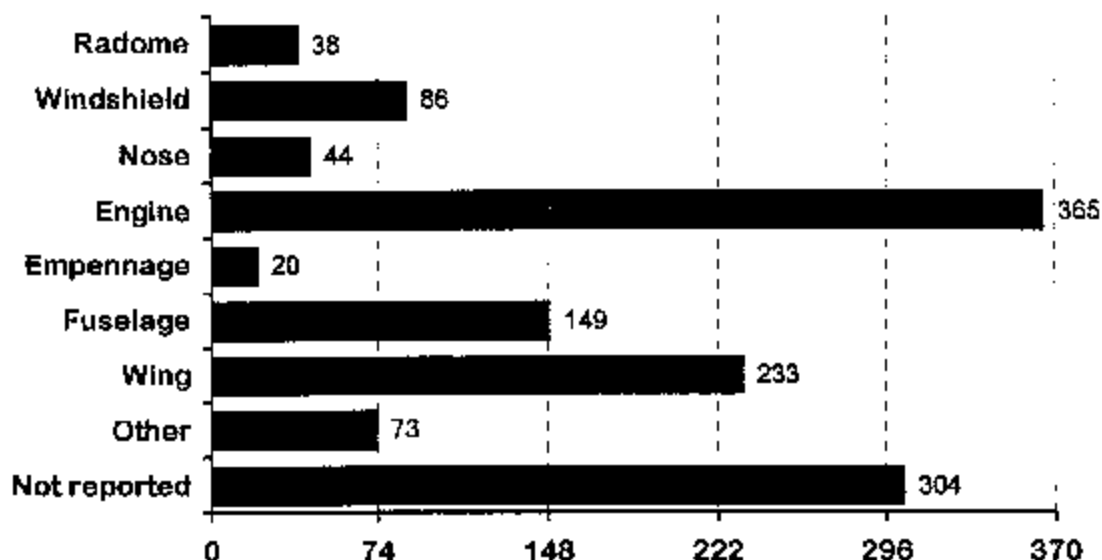


Figure 1 - Parts Struck (1982 to 1996)

Identification of the second item – bird density – requests a detailed study of the local bird population and the migrating birds that cross the area. It is, though, clear that the larger the bird, the higher the severity of a probable accident.

For "Risk Exposure", we have to consider the number of birds and the number of flights sharing the sky in that determined area.

For "Probability", due to the large number of variables involved, we decided to limit its analysis by considering the recent statistics of each region or airport.

4. The Local Problem

When we analyzed our country's bird strike problem for risk, we decided to consider collisions that occurred out of the airports' traffic area as a second level priority on our list, due to the low "**probability**" shown on our statistics – they represent less than 20% of the reported cases.

⁵ ALGE, Thomas L. and MOEHRING, John T. The World Bird Problem Effects on Aircraft, Status of the Problem and Control of the Hazard, presentation at the 49th FSF International Air Safety Seminar, United Emirads, 1996.

⁶ CENIPA, Brazil.

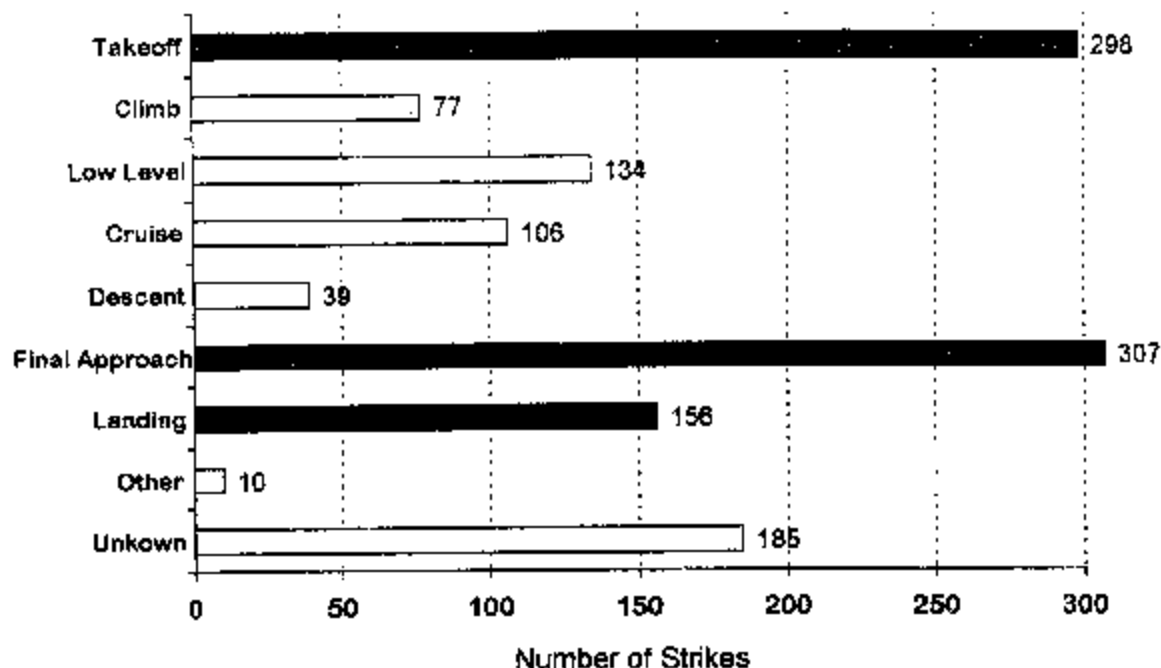


Figure 2 - Reported Bird Strikes per Phase of Flight (1982 to 1996)

We noticed that they are military aircraft flying low level, which will have another type of control action to be commented on later, and a few small low performance private airplanes (lower severity) operating in not controlled airports far from major cities.

Comparing the statistics for each location (1982 to 1996), we could localize the ones with higher number of reported bird strikes.

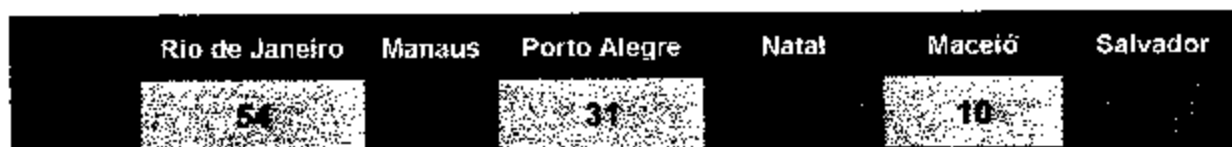


Figure 3 - Reported Events per Location (1982 to 1996)

The airports with reduced jet operations were given a lower priority because of its low "severity" punctuation, though, not shown here.

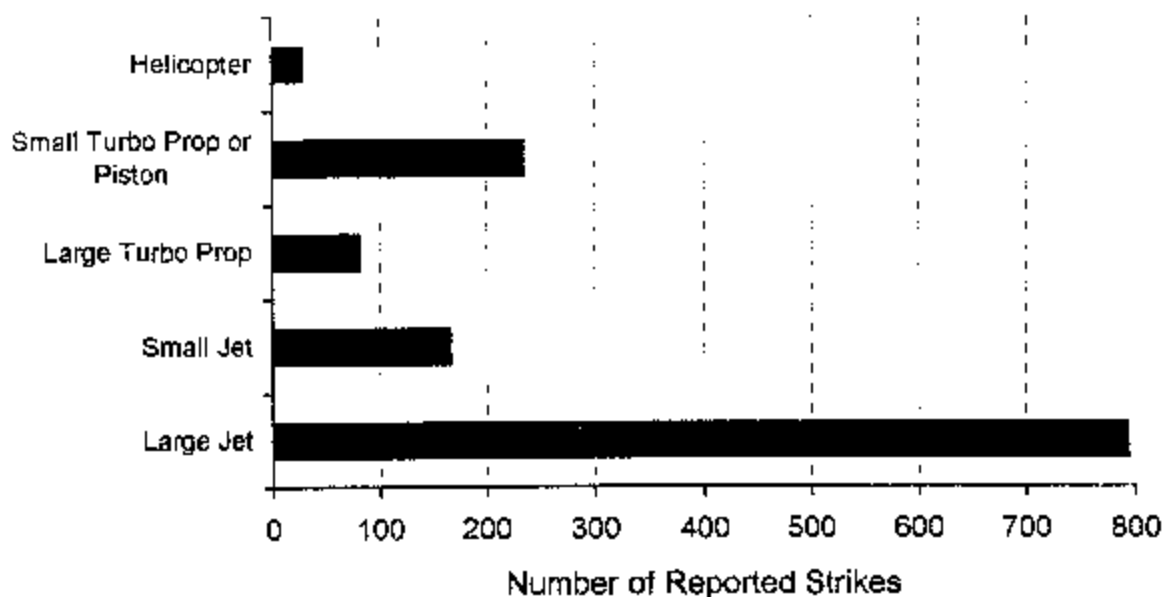


Figure 4 - Reported Strikes per Aircraft Type (1982 to 1996)

Finally, we corrected the data for “**exposure**”, by using the index “strikes per 10.000 movements”, and we got the chart below, that indicates the airports where we should direct our primary attention.

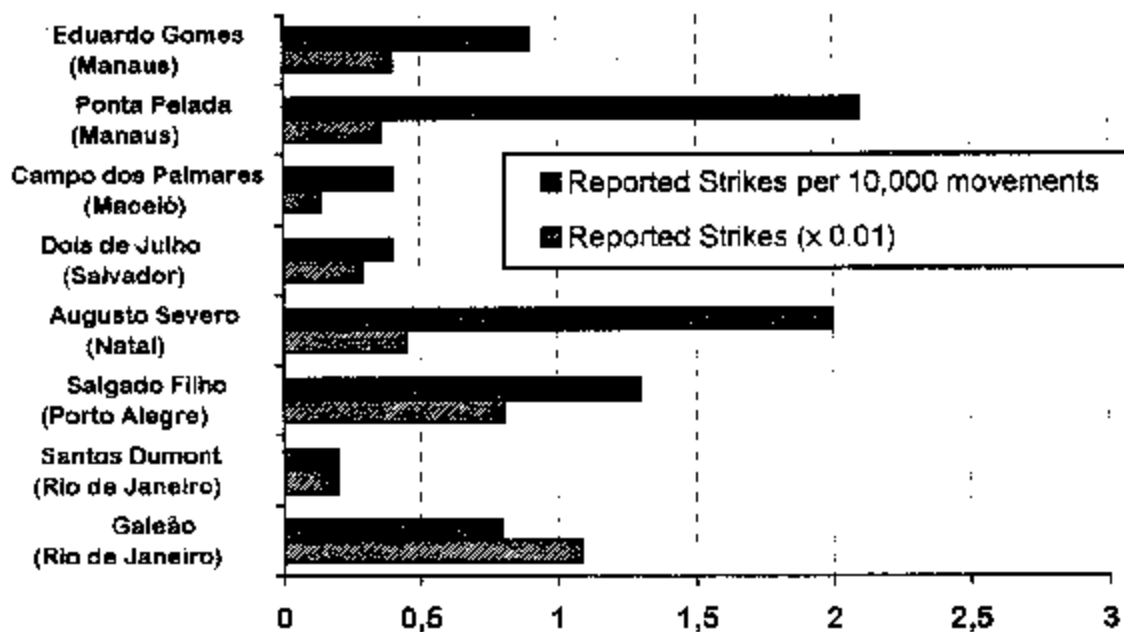


Figure 5 - Reported Strikes per Airport (1982 to 1996)

The map below shows the geographic location of the cities where we detected higher numbers of reported bird strikes from 1982 to 1996.



Figure 6 - South America and Brazil

The next step should be to analyze individually each of those airports, studying not only its statistics but also its environmental conditions.

Starting in 1995, we made helicopter flights⁷ with specialists from the CEMAVE, where we localized, identified and counted the most significant bird species in an area of 20km radius from the airdrome. We estimated their populations and identified problems and potential causes for their presence (natural or not).

On the charts below, we present the numbers obtained for each location (only the birds with notable populations are shown).

⁷ Flights were made in two subsequent days, being two per day (morning and afternoon), always at the same time. Departing from the major airport of the area, we initiated a spiral passing over pre-specified points of interest, where we made one 360° turn to each side, until we reached the 20km limit (approximately 1:45 hour flight).

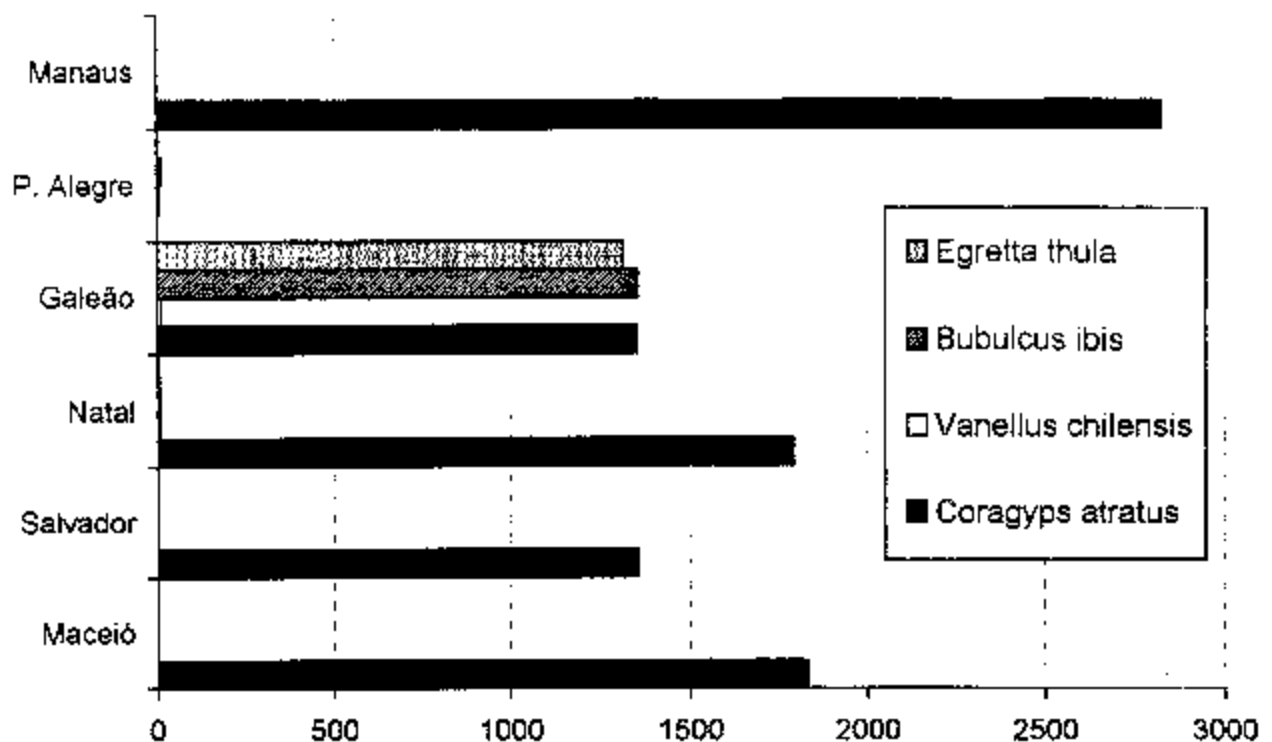


Figure 7 - Observed Species per Location - Top four birds

We can easily infer that there is one bird that is always in large numbers, be it in Manaus or Rio de Janeiro, cities almost 4,000 km from each other: the *Coragyps Atratus* (American Black Vulture or "**Urubu**", in Portuguese).

The "Urubu" is a black bird easily found in the Americas. It eats meat in deterioration, which makes it a very important part of the ecological balance. Because of that, it is very common in landfills and dumps, and usually not found in forests. Its wingspan averages 1.5 m (59 inches) and it weighs around 1.6kg (3.52 lbs). It usually flies in circles using thermals, and is able to reach very high altitudes.

It would not be a surprise to find out from our bird strike data analysis that most of the events in Brazil were related with that bird.

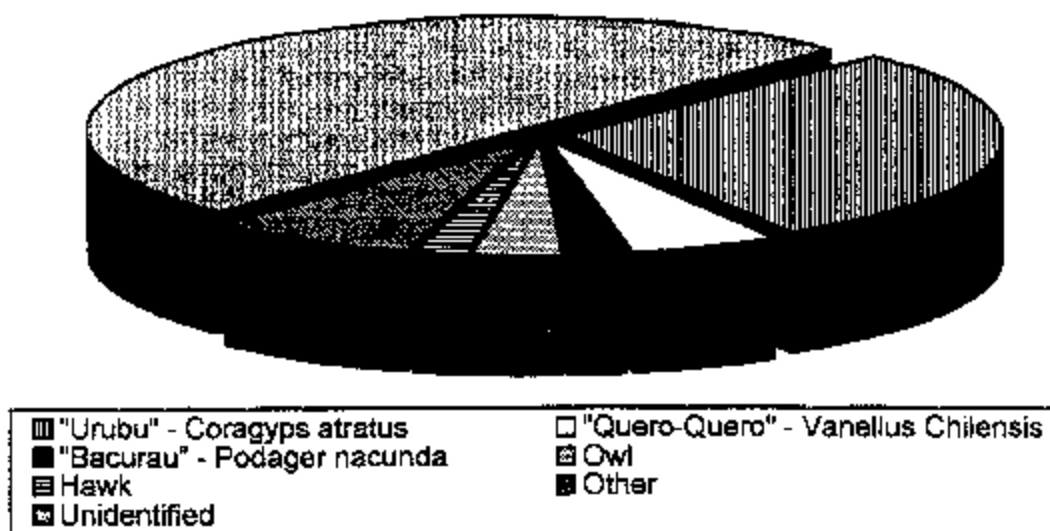
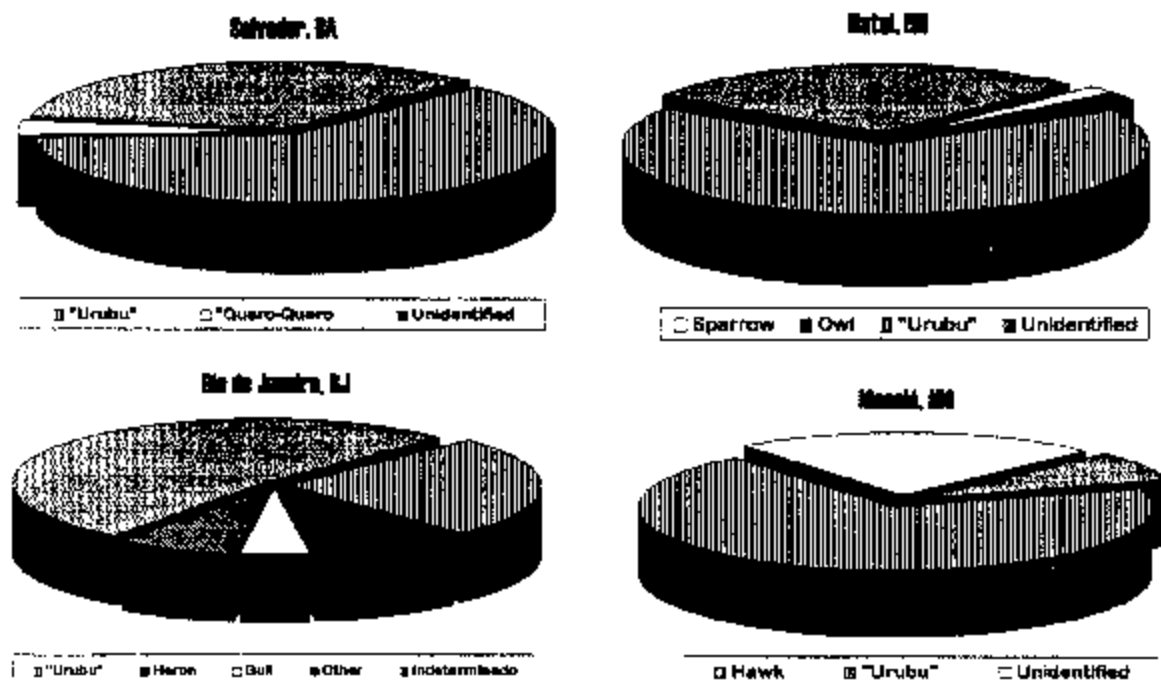


Figure 8 - Type of Bird Involved - Brazil (1982 to 1996)

It is interesting to notice that, when we compare this national data with the same one for the cities with higher reported strike numbers, the predominance of the "Urubu" still persists.



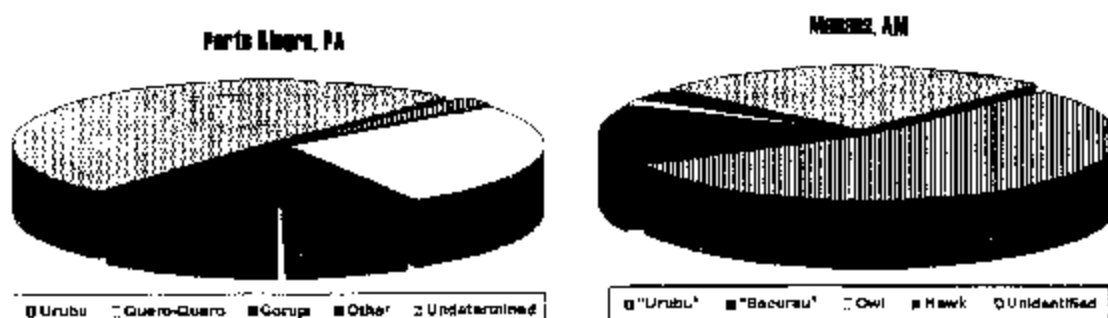


Figure 9 - Type of Birds Involved - Cities with higher numbers of reported strikes

At this point, we knew the bird-problems for each location. We also knew what airports needed priority attention. We then needed to study each case individually in order to develop and implement measures to eliminate or reduce them.

Analyzing each location individually, we found very similar problems, except in Manaus and Porto Alegre, that, even though still maintaining the same major problems, had a second one highlighted (see figure 9). We will discuss these two and then present the problems all airports have in common.

Manaus: City capital of the Amazon state, with a population of 1.2 million, is located in the middle of the Amazon rain forest, isolated from the other cities by a dense forest that only permits communication through the river or the air. It has two major airports 10 km from each other (one is an Air Force Base).

The local statistics (below) shows us characteristics very similar to those of the national situation. However, a second bird, not present in those statistics nor on the bird census done there, appears in very high strike numbers: the "Podager nacunda" (type of Night jar known in Brazil as Bacurau).

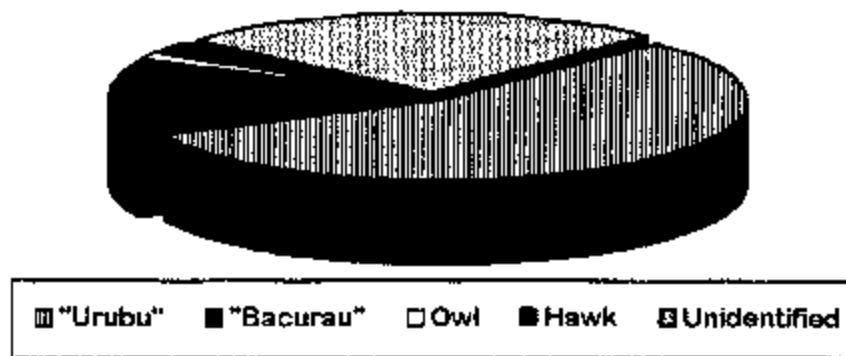


Figure 10 - Type of Birds Involved - Manaus, AM

It is a migratory bird that stays in the area from May to October. It is a night bird (the reason of not being counted on the census) that is found in enormous quantities on the runways' surface, looking for the warmth (the jungle is colder at night) and security of the runways, where it can also easily find food (insects from the ramp lights and worms escaping from the wet soil).

During take-off and landings, the Bacurau turns blind with the aircraft light, staying still until it feels the air vibration and the noise of the aircraft getting closer. Because of that, its reaction is too late, resulting in collision against the coming aircraft (usually multiple strikes).

Porto Alegre: The capital of the most southern state (RS), it is the only major city where the *Coragyps atratus* is not the worse problem (see Figure 10). There, the *Vanellus chilenses* (a type of a Lapwing known in Portuguese as Quero-quero) has its natural habitat in the area surrounding both airports: a large swamp.

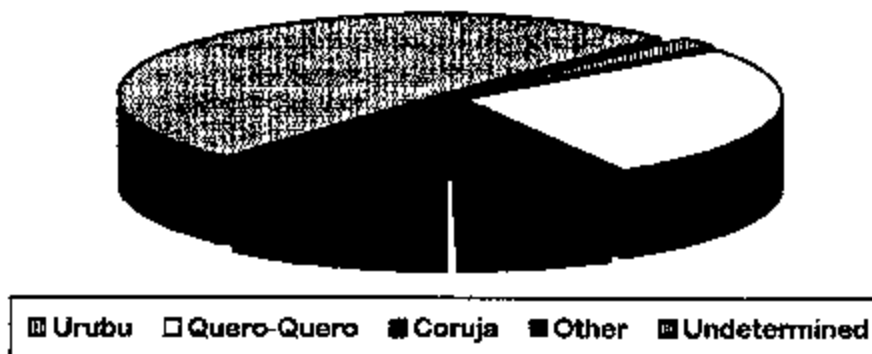


Figure 11 - Kind of Birds Involved - Porto Alegre, RS

On the other airports, without excluding these two, we already know that the Urubu is the bird more frequently hit by aircraft. Analyzing the root causes for such problem, we found the following contributing factors.

- The bird is carnivorous and feeds from putrid meat.
- Flies in groups circling around in thermals and remains for long periods in the same area (over food source).
- In Brazil, 95% of the 240,000 ton of waste produced per day goes to open dumps, receiving minimum treatment.
- In open dumps, we found the largest populations of "Urubus". In the largest dump in Rio, for instance, we counted 1.8 "Urubus" per m².
- Waste landfills and airports share the same needs for geographical space. Both need to be close enough to the city not to make ground transportation too expensive, and far enough not to affect its environment. Besides that, the airport usually has a good road structure, needed for waste transportation.
- Other type of bird (Urubus) attractants are also found close to airports for the same reasons. They are: slaughterhouses, tanning industries and even fishing industries (when applicable).
- Unfortunately, poverty is another possible bird attractant because of poor local sanitary conditions. Most of the areas close to airports, due to their location, are lower priced and usually inhabited by lower income families.

The result is a very common image of airplanes on landing approaches and after take-off passing through flocks of "Urubus".

With most of the local problems known, in 1995, we started developing actions in order to, eliminate, or at least control them, in order to enhance aviation safety.

5. Countermeasures

Because of its characteristics, the most common bird control methods are not effective against the "Urubu".

Falconry does not work, since the "Urubu" is also a top of the line raptor. Besides, it is bigger and in larger numbers than the trained falcon.

Ground deterrents like electronic devices, gas cannons or chemical products do not work either, since the bird is not located on the airport surface area, but in flight.

To manage the problem with these birds, we have to work on its root causes – the reasons why they are so close to airports and even the reasons why they exist in so large numbers.

By law, the Brazilian Ministry of Aeronautics is responsible for the air transport safety. However, it is easy to infer that addressing most of the major factors causing bird attraction to airports and affecting its safe operation, expand its constitutional mandates. It involves numerous federal, state, municipal and even private sectors, from local governments to wildlife agencies, from waste management to residents associations.

National Committee (1995)

In order to deal with such diversified group of organizations, we established, in 1995, the National Bird Strike (Comitê do Perigo Aviário), with representation from many of these groups.

Airport safety areas - ASA (1995)

From that group came the first tool to effectively reduce bird strikes close to airports. The Ministry of Environment signed, in October of the same year (1995), a Resolution (same as law) creating the "Área de Segurança Aeroportuária" – "A.S.A." (Airport Safety Area), where it became prohibited to establish any activity that could cause bird attraction. It includes landfills, slaughterhouses, tanning industries, some agriculture plantations, fish industries, etc. These areas have two different sizes. For IFR operating airports it has a radius of 20km, and for VFR airports, 13km.

Check List (1995)

In 1995 we developed and distributed two check-lists for the use of pilots (civil and military) and airport administration. The first contains preventive actions that a pilot can perform to avoid, reduce or minimize the effects of bird strikes in flight. The second contains environmental control procedures and other effective measures to reduce the presence of birds at airports.

Brazilian Air Force (1995)

Most of the Air Force bird strike events happen during low level flights, with the majority of flights occurring in training areas close to the aircraft's original Base. The exceptions have the same characteristics of the civil aviation, occurring on approaches and

departures to the same airports mentioned before (some Brazilian Air Force Bases are dual-use with civilian airports).

With that in mind, we implemented a simple system where the areas known to have large bird flocks are marked on a large map of each training area. These maps are posted in mission planning rooms and AIS facilities⁸. We also standardized discussing bird strikes risks and collision avoidance procedures by pilots during mission briefings.

We understand these measures are not the only ones needed to effectively control the problem, but it has already shown some positive results, proving to be very cost-effective.

Bird Strike Seminars (1995, 1996 and 1997)

Because of the difficulties in fixing the identified problems, due to the large variety of government institutions and civilian organizations involved, we decided to promote a series of one-day seminars in the cities with higher bird strike rates. For each seminar we invited each industry and local government department directly or indirectly related to the bird attraction problem. We also invited local aviation companies, airport administration, pilots, universities and the media. These seminars' goals were not only to discuss the local problems with all sectors involved, but also to present them information they might not even have known, and to call society's attention in order to bring it to our side, pressuring governments to do something about it.

During the seminars, we presented the risk of aeronautical accidents caused by bird strikes (most of the audience did not know it until the seminar), the report of the evaluation flights done a few weeks before, the environmental impact of the deficiencies detected, and the legal aspects of an accident caused by bird strike (the source of attraction can be prosecuted). The seminars ended with a discussion open to the audience, where new solutions were presented and many of the desired actions were finally assumed by the legally responsible parties.

The seminars have been very effective, with a variety of initiatives being performed in most of the cities, but probably the best result has been the increased awareness of all segments of the local society for the risks involved and their responsibilities in reducing them, resulting in initiatives that we did not expect to see (to be discussed).

The New Fauna Protection Law (1996 - 1997)

Brazil has one of the most restrictive laws in the world for animal protection. It is so aggressive that it protects even the "Urubu", that can, with its almost two kilograms,

⁸ Air Information Service - AIS

cause the crash of an airplane on final approach with 150 passengers and maybe other 50 people on the ground -- Killing a bird in Brazil is a crime with no parole.

A new law proposal has been written and it is now in Congress for evaluation. We took part in some of the discussions and included a new paragraph that allows the Ministry of Aeronautics, who is in charge of the air transport safety, to directly request the local responsible agency of the Ministry of Environment to execute adequate bird control measures, when their presence affects aviation safety.

Comics Book (1996)

After the seminar, which occurred in Maceió in 1996, local organizations developed a small comic book for children about the bird strike risk. The magazine explains, with very simple language and drawings, the risk of accidents caused by bird collisions, the causes of bird attraction, the effects of such accident and the actions that everyone can take in order to reduce the problem.

The comic books were targeted at low-income children of the outskirts areas that are close to the airport. They were distributed in schools and residences of the region.

Children performance (1996)

Another fortunate product of the Maceió seminar was the creation of a group of children that developed and performed a theatrical presentation about the matter. Presented in the schools of the city, the performance showed exactly the same topics – risk, causes, effects and corrections to the problem – educating children about basic sanitary aspects and motivating them to contribute to quality of life improvement.

The Salvador (BA) Program (1996 - 1997)

As a result of the actions taken in Salvador (BA) in accordance with the Bird Strike program, especially the seminar held there in 1996, the state government contracted a consultant to present a program proposal to control factors contributing to bird presence close to the city airport.

Their work is complete and is probably being given to local authorities by this month (November). Amid the proposals are suggestions to relocate the city dump and provides guidance for construction and management of a new landfill.

Government has received funds from BIRD⁹ for this project, which indicates not only the seriousness to attack the problem, but also the high possibility of achieving effective action.

The Bacurau in Manaus, AM (1997)

For the "Bacurau" problem on the two Manaus airports, we decided to combine deterrent systems: Gas cannons and Methyl Anthranilate¹⁰.

The use of falconry would not be efficient because the problem happens at night. The gas cannon, on the other hand, since it can only be used for a limited period of the year (March to September), only at night, and only when there is aircraft operation (the airports have low night operation), it would not allow birds to adapt to it, which is the worse defect of this method. Combining it with the use of the Methyl Anthranilate, we believe we can improve both effects (tests were initiated recently, and results are not available yet).

The cannon, installed for testing on one runway since June, appears to be efficient – we are now analyzing the reports. The only difficulty was to determine the exact timing for igniting the cannons before aircraft passage, to avoid making the problems even worse, since instead of hundreds of birds on the runway, we could have them in the air, right in front of the aircraft.

The other positive effect noted was the elimination of dogs on the runways, a common problem there.

Video tape (1997)

We have just finished producing a video tape about bird strikes for the aviation community. In 45min, we present the problem and possible solutions, and include the pilot and airport check-list. They will be distributed, at no cost, to airlines, aviation schools, airport administration and other aviation related organizations.

To be done

There is still a lot to do, but some of the next actions are, if not yet started, at least planned. Some of these are listed below.

⁹ International Bank for Reconstruction and Development.

¹⁰ Methyl Anthranilate is the basic ingredient of products like Airport Shield (BSRC - PO Box 785, Pullman, Washington 99163-0785) or ReJex-IT TP-40 (RJ Advantage, Inc. - 501 Murray Road, Cincinnati, Ohio 45217-1014) that disperse birds by irritating birds eyes' and mucous' membranes without harming them.

- Re-issue of the comic book, in order to improve its quality for a wider distribution.
- Development of a series of local school contests about the topic in low-income schools of the cities with worse problems, where we would also present the Maceió performance group, for incentive.
- Signing of a contract (November) with the Post Office, to make the Bird Strike Report form CENIPA 15 and 15-A into a folding, pre-paid postage form, improving simplicity and reporting.
- For Porto Alegre (RS), where we have problems with the "Quero-quero" (see page 12), we started contacting falconry trainers in order to start a local program. We believe that, for this case, it could be effective.
- Development of a new legislation with the IBAMA, authorizing the airport administration to kill birds (inside its area only) that affect operation' safety.
- Decentralization of local bird control: We already initiated a program with the INFRAERO (national airports management agency) in order to decentralize bird control by transferring it to each airport administration. Managers are being indicated and will be sent to CENIPA for a training course and to be oriented on developing their Airports' Bird Control Programs.
- Besides decentralizing the Bird Control Programs, we will also decentralize most of the National Bird Strike Reduction Program, transferring to our elements in the main regions (SIPAER is divided in seven regions, where we have someone above the aviation safety specialists). We believe it was necessary to centralize when starting the program because of the absence of technical know-how and the need to standardize procedures. We believe it is now time to let the system work by itself.

6. Conclusion

Reducing bird strike accidents and incidents is a goal of a large number of aviation safety specialists around the world. Millions of dollars have been spent by the air transport industry, including airlines, aircraft manufacturers, safety organizations, airlines, etc.

In Brazil, the aviation industry has had a tremendous growth during the last few years, achieving traffic volumes¹ and airport movements in certain regions that compare to some first world countries. On the other hand, basic problems associated with the unorganized growth of certain regions tend to impose proportionally increased risk for aviation safety, exactly on the airports with larger operations.

A centralized, low cost, but effective Bird Strike Reduction Program needed to be implemented, and has shown in only a few years of activity some very reasonable results.

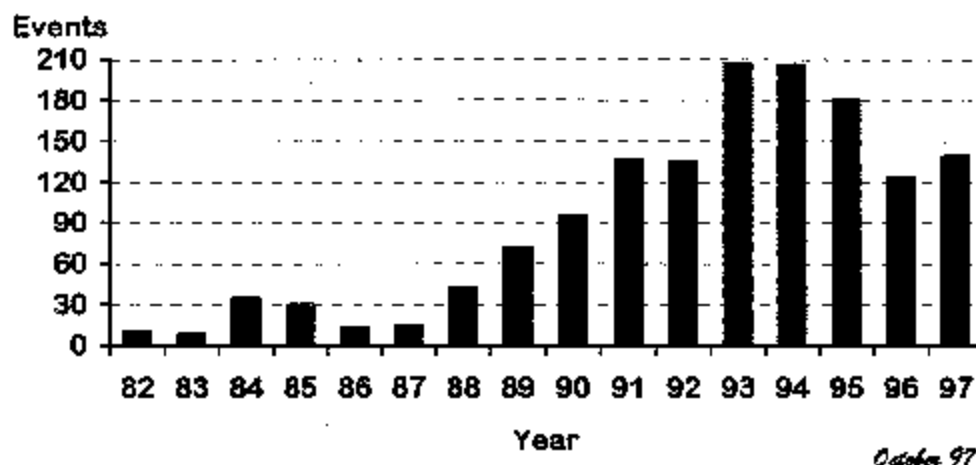


Figure 12 - Reported Bird Strikes per Year - Brazil

Some of the most important problems have been resolved, some others are already determined. The program is reaching maturity, and its decentralization is an indicator of that. However, we are aware that a lot still has to be done.

Last years statistics indicate that we are on the right track, and the persistency in continuously striving to achieve higher levels of aviation safety standards will certainly guarantee better life conditions to our people – which is the final goal of our activity.

¹ The Brazilian Aircraft Registration System (RAB) has 10,560 aircraft.

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APPENDIX 34

Stephenville Airport Bird Survey, 1997

Stephenville Airport Bird Survey

August 5 - September 10, 1997

**Transport Canada
Stephenville Airport
13 Tennessee Drive
Stephenville NF A2N 2Y3**

**(709) 643-8020
e-mail: snowda@thezone.net**

Introduction:

This report presents the preliminary results of a comprehensive survey of bird population and activity at the Stephenville Airport during the period 5 August to 10 September, 1997. Sufficient surveys have been completed that inferences with respect to population and location can be drawn.

Methodology

Observations on the location, species, activity and numbers of birds on and around the airport were taken between the hours of 06:00 and 20:00. During the survey period, 90 surveys were completed. The observations were made by the Airport Manager, the Manager, Safety and Security and the firefighting staff.

The airport was divided into a grid which separated the lands into 16 sectors. The number, species and activity were recorded for each sector during the survey. The information was entered on a form designed for this purpose (see appendix for a sample form). With the expectation that weather conditions would be a factor in the bird population, each survey included the sky conditions, winds and temperature at the time of each observation. (No correlation of weather and population have been made as of this time.)

The activities observed were classified into Roosting, Feeding and Flying. Roosting was defined as any behavior where the birds were apparently resting as opposed to feeding (i.e. that the bird was not standing at the time of the observation). For greater clarity, all observations of birds standing were assumed to be a feeding activity. The activity was classified as much as possible prior to the intrusion by the surveyor. Therefore, if the birds flew away as a result of the surveyor's intrusion, the activity was not recorded as flying, but rather Feeding or Roosting as appropriate.

Attempts were made to conduct the survey during all daylight hours. The times of the survey were recorded under the applicable Block Hour (i.e. 06:45 was recorded as 06, 07:05 as 07, etc.) If scare tactics were used by the surveyor, the type and result was recorded.

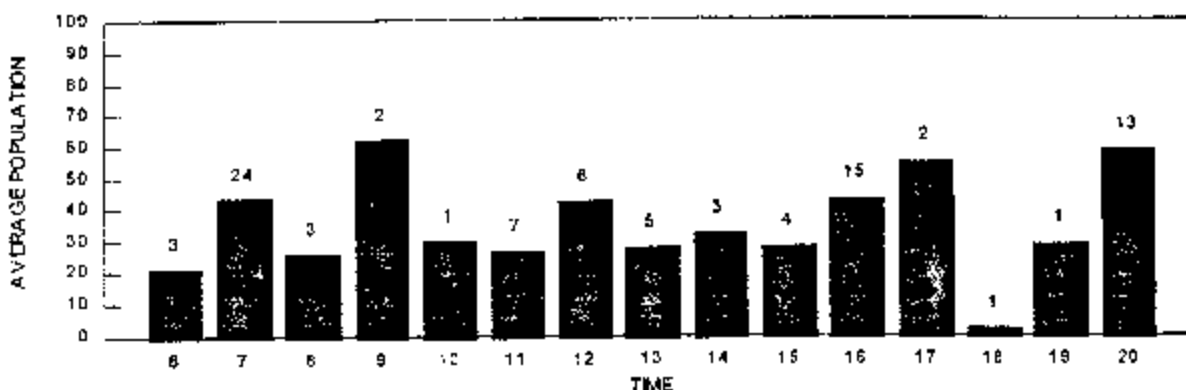
Results:

1. Overall Population:

The bird population varies throughout the day and is concentrated on Runway 10-28 and North. The higher-than-average populations occurred in the 07:00 to 08:59 and 16:00 to 20:59 periods.

STEPHENVILLE AIRPORT BIRD SURVEY

AVERAGE POPULATION OF BIRDS, AUGUST 5 - SEPTEMBER 10, 1997

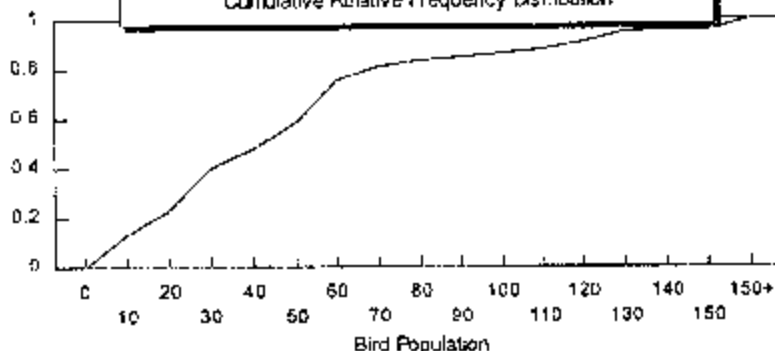


NUMBER OF OBSERVATIONS PLACED ABOVE EACH BAR

The average airport population was 41 birds. There were over 100 birds approximately 10% of the time:

Stephenville Airport Bird Population

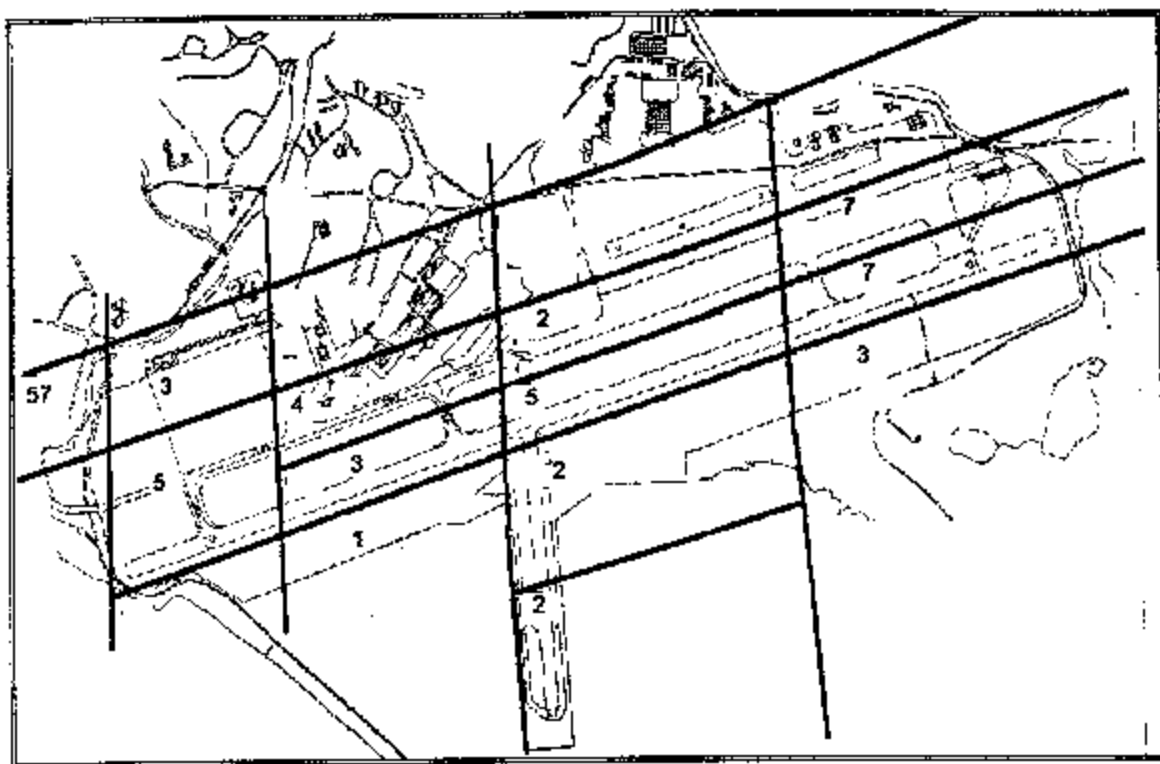
Cumulative Relative Frequency Distribution



Cumulative Rel Freq

2. Population and Location:

A very high concentration of birds (primarily, gulls) occurs to the north of the Runway 10 approach. On average, there were 57 birds in this location. This is a large area of abandoned concrete ramp which the birds use for roosting. These birds were not included in the average airport population.

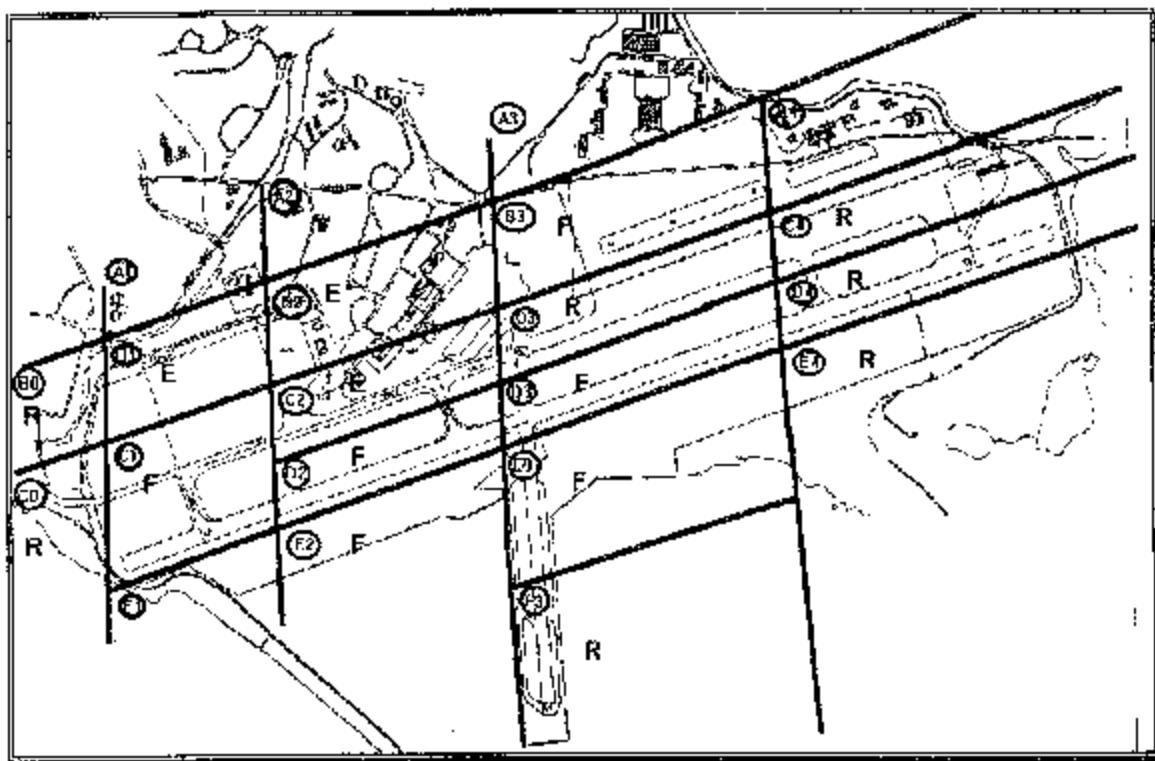


The numbers on the map above are the average number of birds observed in each of the sectors during the survey.

3. Activity and Location:

The primary activity of the birds was roosting, particularly on the east side of the airfield. Eating activity was mainly to the northwest and flying activity to the south. Of particular concern is the high incidence of flying over the approach to and alongside of runway 10 (or, on the climbout portion of runway 28):

PRIMARY ACTIVITY BY LOCATION:

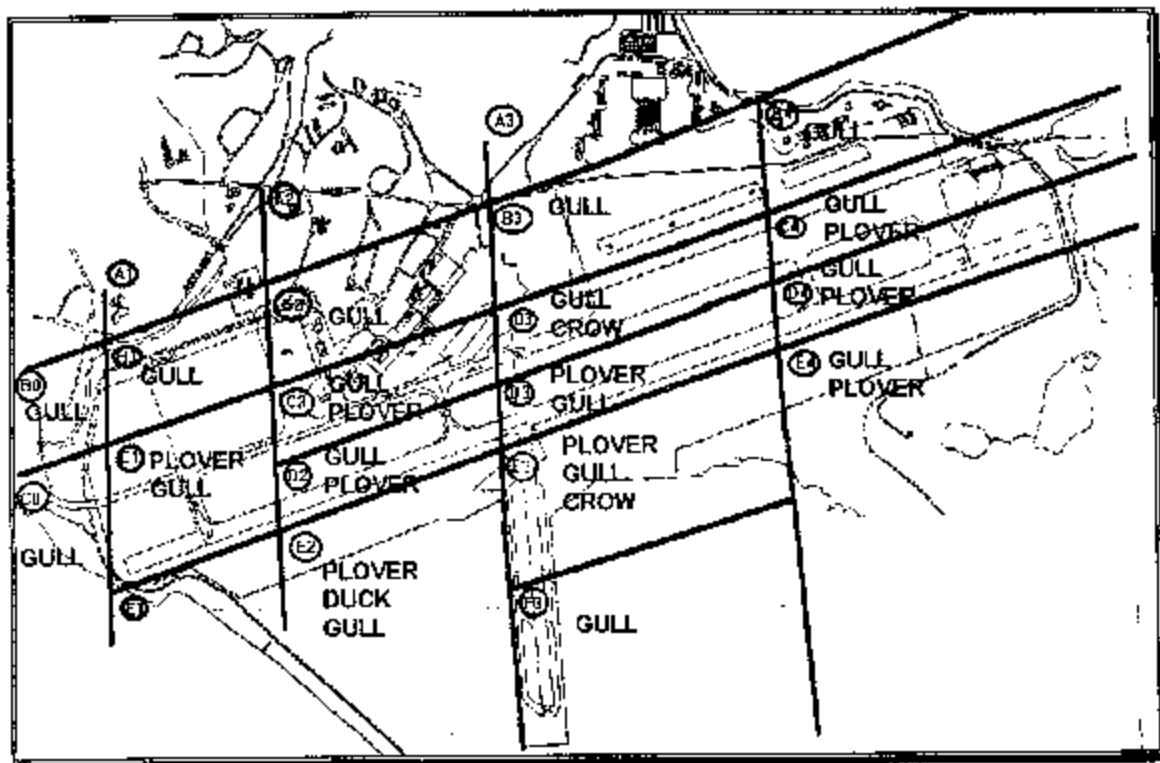


Legend: R = Roosting; E = Eating; F = Flying

4. Species and Location :

The predominate species was the Gull, followed by the Plover. The Gull and the Plover are endemic throughout the airport property.

The predominate species in each area is indicated in the following map. Where more than one species is indicated, the species are listed with the most common species first.



Although the Crow is listed only twice in the above diagram, small numbers were observed throughout the field. The preponderance of Gulls and Plovers tended to make the Crow proportion small. The Crow, however, is a large bird and of considerable danger to aircraft.

There was a scattering of robins, swallows, killdeer and one hawk observed during the survey. The number of these other species was considerably smaller than the more common ones.

Recommendations and Future Action:

Although the survey was conducted for a short time, the preliminary results are being distributed to those agencies with an interest in the findings, including Air Atlantic, Interprovincial Airlines, St. John's FSS, Aerodrome Safety staff in Moncton and the Aerodrome Safety Wildlife Specialist in Ottawa.

The preliminary results indicate that frequent and regular bird patrols are required to monitor and, where appropriate, disperse the bird population. Contact with the Town of Stephenville with respect to the roosting gull population adjacent to the 10 Approach is also needed.

The survey itself will continue on a regular basis until we experience snow cover sufficient to, as past history has shown, deter a significant airport bird population. This will cover the bird migration patterns of the fall season.

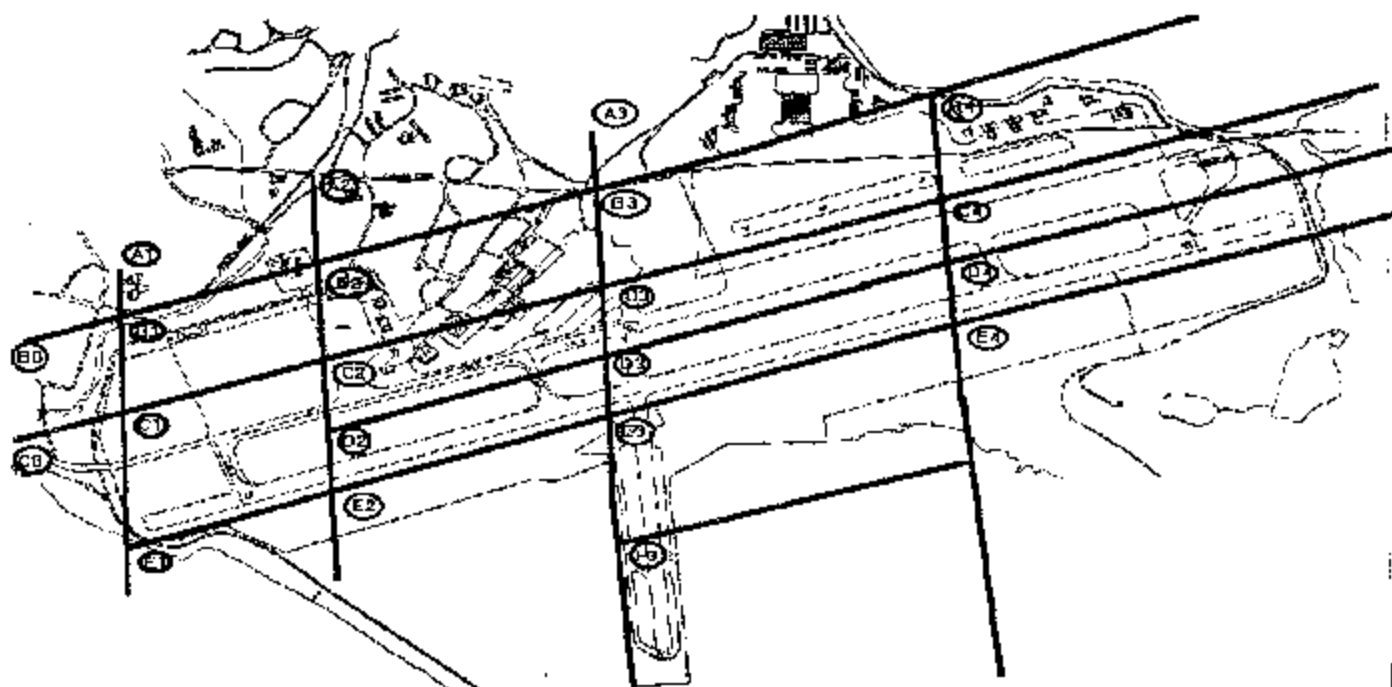
As the survey database is enlarged, the preliminary results will be assessed against a longer base-line and, should any significant variances be observed, all parties will be contacted.

Finally, an airport bird management control plan will be developed, highlighting the sources of attraction and possible mitigation techniques. Past practices of shooting and scaring the birds has been mildly effective but not sufficient to achieve a reduced bird population. Attention will be placed on insect and vegetation control and remotely-activated scaring equipment for next year.

Copies of the survey database, in dBase IV format, is available by contacting the Airport Manager. Any suggestions and/or experiences readers can share are also welcomed.

Appendix

STEPHENVILLE AIRPORT BIRD SURVEY



DATE: ____/____/____ TIME: ____:____ OBSERVER: _____

LEGEND:

SPECIES:

G=GULL

C=CROW

D=DUCK

O1=OTHER _____

O2=OTHER _____

ACTIVITY:

F=FLYING

R=ROOSTING

E=EATING/FEEDING

EG: 10GF= 10 GULLS FLYING

WEATHER OBSERVATIONS:

SCARE TACTIC & EFFECT

REMARKS:

GULLS

Biology

Ring-billed Gull (*Larus delawarensis*): male — 566 grams; female — 471 grams*
 Herring Gull (*Larus argentatus*): male — 1226 grams; female — 1044 grams*
 Franklin's Gull (*Larus pipixcan*): 280 grams; range: 220–335 grams*
 Glaucous-winged Gull (*Larus glaucescens*): 1010 grams; range: 730–1400 grams*

Gulls are involved in the greatest number of on-airport bird strikes probably because of their great liking for the airport environment and their flocking characteristics. They prefer to feed and rest in flat, wide-open spaces with little groundcover or very short grass, (e.g., parking lots, golf courses, and airport runways and infields). Usually associated with water bodies, gulls will often travel considerable distances overland in search of good feeding areas. Depending on the species, gulls nest in variable-sized colonies (up to thousands), usually on the edge of a water body. Gulls may arrive at roosts after nightfall which presents the possibility of a serious bird strike risk after dark.

Immature gulls, usually seen in late summer, often cause the greatest problems on airports because of their relative ignorance of aircraft. Most gulls migrate south in the fall, but some spend the winter in southern areas of Canada near good food sources.

The Ring-billed Gull

A common medium-sized gull in the Great Lakes area and central Canada. The adult is identified by the distinctive black ring around the end of its beak. It is the major problem species on airports in the Great Lakes area. Young Ring-billed Gulls have a distinct black band on their tail (see illustration). The Ring-billed Gull is extremely social and will travel long distances in search of food.



Ring-billed Gull

Herring Gull

A common, large gull found throughout Canada, except the southwest prairies. The adult is determined by its large size and the red dot on its beak (no black). Young Herring Gulls do not have a distinct band of black as Ring-bills do (see diagram). The Herring Gull is not quite as sociable as the Ring-billed and it is not as common far from water.

Franklin's Gull

A small gull of the prairies, black-headed in the spring. It feeds heavily on insects in prairie fields. In the northern prairies, the very similar Bonaparte's Gull is found.

Glaucous-winged Gull

A large, mostly white (dark wing tips) gull of the west coast.

Food and Attractants

Gulls are attracted to water bodies (lakes, ponds) as well as to wide-open, flat areas for feeding and nesting. They often just loaf in parking lots and on runways (usually after feeding). Gulls are essentially scavengers and they have extremely variable food preferences: insects, earthworms, grubs, sprouting vegetation, food waste, small animals (dead and alive), fish, berries, and small fruits. They forage for these foods in the following habitats: short-grass fields, freshly ploughed fields, garbage dumps, restaurant areas, picnic areas, beaches, shorelines, shallow water, waste treatment plants, and airports.

Control

Habituation to most control methods is a major problem in gull control. The following measures can be effective, particularly when they are combined in a multifaceted control program.

- maintain grass at 10 to 15 cm (4 to 6 inches) or longer
- eliminate areas of standing water by using improved drainage
- eliminate all on-airport garbage-producing outlets, including picnic areas and all flying paper
- use scare tactics: persistent harassment of gulls has been shown to be effective in reducing the total numbers over the long run. Shell crackers and flares that are reinforced with live ammunition, distress-cry tapes and falconry are effective
- remove gulls with live ammunition (#4 steel shot)
- exclude gulls from water bodies by using suspended wires
- use worm-inhibiting chemicals, (e.g., benomyl or tersan)
- destroy or eliminate other food-producing sources: berry bushes, insects (insecticides or vegetation management)
- modify agricultural practices, (e.g., plough at night)

Similar Species: Bonaparte's Gull (similar to Franklin's) in central and northwest areas, Great Black-backed Gull (very large with black back) in eastern areas, Glaucous Gull (large, no black on wings) in the far north

POVERS

Biology

Golden Plover (*Pluvialis fulva*): 153 grams; range: 122–192 grams*



Plover

Plovers are a group of small to medium-sized shorebirds that includes many regionally distributed species. The Killdeer and Golden Plover are two species common on airports. Both species nest in dry, short grass and gravelly fields; the Golden Plover in the far north tundra regions and the Killdeer throughout southern Canada and into the north. Being migratory birds, most plovers are observed in flocks during the fall migration. The Killdeer is commonly seen in pairs or small groups throughout the summer. These field species prefer open habitats with little undergrowth, as at airports. Plovers are similar to sandpipers, but they can usually be distinguished by their short beak and short, thick neck and body.

Food and Attractants

Plovers feed on small insects, crustaceans, grubs, and worms that they find in the surface soil of wet ground areas (fields, mud flats) and shallow water. The Killdeer and the Golden Plover frequent dry areas such as short-grass fields, freshly ploughed fields, and gravelly areas.

Control

Habitat manipulation measures are most suitable.

- elimination of wet areas such as ponds and wet depressions through improved drainage
- grass maintenance at 10 to 15 cm (4 to 6 inches)

Scare tactics should be used in peak migratory periods: shell crackers, gas cannons, falconry.

Similar Species: Black-bellied Plover, Ruddy Turnstone, Semipalmated Plover, Sandpipers (see text)

AMERICAN (COMMON) CROW

Biology

Corvus brachyrhynchos: male — 458 grams; female — 438 grams •

The American Crow is a common, large, black bird seen throughout Canada, north to the tree-line. It is very adaptable and it is found in all habitats—forests, agricultural areas, cities, towns, open fields, and garbage dumps. It often is observed in variable-sized flocks (5 to 50), but it may also be seen singly or in pairs. Owls are an arch enemy, and large numbers of crows will congregate to harass roosting owls during the day.

Food and Attractants

The American Crow eats almost anything and it is found in many areas foraging for grains, vegetables, berries, and dead animals. It is particularly attracted to corn fields, grains (and stubble), garbage dumps, sprouting plants, and Meadow Vole nests. It generally roosts in tall, prominent trees.

Control

The crow is highly adaptive — habituation to many scaring techniques is a major problem. The crow also tends to be quite wary of approaching humans. Suitable methods for control include:

- habitat modification: manipulation of agricultural crops and general clean-up of garbage areas, animal carcasses, and food production areas
- scare tactics using a variety of methods randomly combined with reinforcement by live ammunition

Similar Species: Raven (north and far north); Northwestern Crow (west coast).

APPENDIX 35

Bird Strikes! - FOCUS, August 1997

FOCUS



Received - Recd
Issue 1/97

AUG 26 1997 August 1997

AAEM

BIRD STRIKES! Bob G.



BIRD STRIKES!

(a DFS-ADF *FOCUS* Flying Safety Publication)

The information in this issue of *FOCUS* was researched and compiled by SQNLDR Michael Price, P-3C Orion Desk Officer and Training Officer DFS-ADF, and prepared for publication by the Editorial and Graphic Design Cell, DFS-ADF.

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August 1997

BIRD STRIKES!

Military aviation is concerned with mission capability. Accidents or incidents involving bird strikes on military aircraft reduce our mission capability. Long periods without incident tend to breed complacency. The danger is to believe that it can't happen in the ADF or that it can't happen to you.

Seven years ago DFS published *Focus 1/90: Birdstrike*. Included in this publication were ADF bird strike statistics for the period 1985-1989. Since this period there has been a decline in the number of reported bird strikes and this has been most evident since the introduction of the ASOR in September 1993, when the emphasis was shifted to reporting human factors incidents.

Birds continue to be a potential hazard to military aviation, particularly to aircraft operating below 2 000 ft AGL where the majority of bird activity occurs. Fortunately, the ADF has not had a major bird strike incident for some time but aircraft, nonetheless, continue to hit birds.

Despite their size, birds can cause considerable damage, generally due to the high speed of aircraft. Some of the articles in this edition of *Focus* are testimony to that. Many of the major bird strike accidents and incidents occur in North America and Europe where there is a large migratory bird problem. Despite this lack of large migratory bird populations in Australia, aircraft operating locally continue to experience bird strike-related incidents.

DFS-ADF encourages the reporting of bird strikes (and close calls,) which do or have the potential to create a safety problem, so that this information may be tracked and used to determine trends which may help aviators and airfield managers prevent another major aircraft accident or incident.

Much of the information in this publication has been sourced from overseas as there appears to be very little literature published on bird strikes in this country. However, whether the bird strike information has originated in the United Kingdom, United States, Canada or any other country, basically the same principles of prevention apply world-wide.

The AWACS tragedy at Elmendorf, Alaska understandably attracted a lot of media attention. The article on page 5 covers the accident from the crash to the disciplinary action taken against those found responsible in some way for not taking steps to prevent the accident.

If you have information, or suggestions on how to further reduce the incidence of bird strikes in the ADF, do contact us so that we can either act upon it or pass the matter on for action elsewhere. Our contact details are on page ii. →



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COVER PICTURE

Damage inflicted to the radome of F-111C A8-138 on 19 August 1987 after a duel with a wedge-tailed eagle (complete with rabbit in claws). Readers will readily identify the pilot: DCAF (Air Vice Marshal Errol McCormack - then Group Captain and OC 82WG). The navigator was Flight Lieutenant (now Wing Commander) Mike Bennett.

The F-111 took off from Townsville at 1515 hrs for a return flight to Amberley. The task included a low-level toss attack simulating an LGB (laser-guided bomb) delivery on Moura Mine in western Queensland, using a range of hills with a cliff face as the JP - as was the eagle! While flying at 400 ft AGL and accelerating to 540 kts, AVM McCormack first spotted the eagle just prior to impact. He immediately pulled hard and positioned the aircraft's nose between the eagle and the navigator's windscreen. (At this time the navigator was head down in the 'bucket' (radar shroud) attempting to identify the target on radar.)

At impact the majority of the lights on the emergency panel illuminated and it was some seconds before the crew realised that the radar nose cone had been penetrated and that all pitot-static instruments had been rendered useless. Nevertheless, after declaring a PAN the crew were able to continue to Amberley at 3 000 ft and 300 kts using INS data, and subsequently landed without further incident.

Damage to the front of the aircraft was extensive (Category 2) although, fortunately, both engines escaped FOD damage. Of interest, when the F-111 was parked back at the Amberley lines the radome, which had 'inverted' after impact, disgorged most of the radome wreckage onto the ground and the eagle/rabbit remains!

Wing Commander Bennett is presently the Deputy Director, Concepts and Capabilities in Australian Defence Headquarters, Canberra.

→

BIRD STRIKES

Looking at the problem

AS mentioned in the foreword to this publication, military aviation is concerned with mission capability. Accidents or incidents involving bird strikes on military aircraft reduce our mission capability. Long periods without incident or accident tend to breed complacency and the danger is to believe that it can't happen in the ADF or that it can't happen to you. The following incidents show that bird strikes are a serious problem in the ADF and that you could well be the next incident - or worse.

- Mirage: ingested birds after take-off resulting in compressor stall and subsequent pilot ejection.
- P-3B: struck pelicans which destroyed the radome and narrowly missed activating the engine shutdown handles.
- F-111: struck pelicans, both crew were killed.
- F-111: struck a wedge-tail eagle (and rabbit) which caused complete disintegration of the radome and loss of all airspeed references.

The following is an extract from the accident investigator's report on the crash of F-111 A8-133 which crashed at Evans Head Range, NSW on 29 September 1977.

Investigation of the wreckage revealed that three separate bird strikes had occurred. All of these hit the forward cockpit windscreen and at least one bird penetrated into the cockpit area. Pieces of windshield, canopy, helmet visor cover and helmet visor were found 1 500 - 2 750 metres prior to the aircraft impact position. The aircraft's altitude and airspeed were calculated to be approximately 2 000 ft AMSL and 465 kts at bird impact.

The glass from the crushed windshield and the bird remains, plus the extreme turbulence, noise and vibration, made the cockpit environment untenable.

The instructor pilot initiated the ejection sequence approximately ten

seconds after the initial bird impact. Actual separation occurred 0.35 seconds later at about 700 ft AMSL and at a speed of 520 kts. The escape module was outside the ejection envelope at that time. The aircraft mainframe crashed in a 30° dive angle and right-wing low. The module travelled 298 ft past the primary crater and broke up on ground impact. Both crew were fatally injured.

The F-111 accident investigation determined that:

- the aircraft suffered at least three bird strikes;
- the windshield broke inwards, disabling and effectively blinding the crew;
- the ejection sequence was initiated outside the effective survival envelope;
- the aircraft and escape module were destroyed in the resultant crash; and
- both aircrew suffered fatal injuries.

What can we do?

General. Agreed, bird strikes are an operational hazard, but there are certain steps that can be taken to reduce the risk of a bird strike.



P-3B Orion, damage suffered from encounter with a pelican.

	86	87	88	89	90	91	92	93	94	95	96	TOTAL
B707	-	1	1	2	3	1	2	-	1	-	-	11
BLACKHAWK	-	-	1	5	8	1	2	1	-	-	-	18
CARIBOU	4	4	3	1	7	3	2	-	1	-	-	25
CHINOOK	2	-	-	-	-	-	-	-	-	-	-	2
CT4	5	3	1	8	8	1	-	-	-	-	-	26
DAKOTA	-	-	-	-	1	2	-	1	-	-	-	4
F111	29	29	17	20	22	18	6	6	-	1	3	151
F18	2	1	11	6	5	4	9	6	3	2	1	50
FALCON 900	-	-	-	-	1	1	5	4	1	-	-	12
HERCULES	29	22	26	45	43	41	31	16	-	-	1	254
HS748	4	5	4	4	7	6	4	-	3	-	1	38
ILLINOIS	12	2	2	-	-	1	1	-	3	-	-	21
KIOWA	2	3	4	2	4	4	4	-	-	-	-	23
MACCHI	16	15	10	12	6	10	5	2	-	2	-	78
MIRAGE	14	6	2	-	-	-	-	-	-	-	-	22
NAVY B206	-	-	-	-	-	-	-	-	1	1	-	2
NAVY HS748	-	-	-	-	-	1	-	1	1	1	1	5
NAVY SQUIRREL	-	-	-	-	2	1	-	-	3	-	-	6
NOMAD	1	-	1	3	4	4	-	-	-	-	-	13
ORION	15	9	7	21	11	18	9	4	-	4	-	98
PC9	-	-	-	1	3	8	1	3	10	3	6	35
PORTER	-	1	1	1	-	-	1	-	-	-	-	4
SEAHAWK	-	-	-	-	1	1	1	-	-	1	1	5
SEAKING	-	-	-	-	-	1	-	-	-	2	-	3
SQUIRREL	-	-	-	1	1	3	1	-	1	-	-	7
TOTAL	135	101	91	132	137	130	84	44	28	17	14	913

Table 1 - Bird Strikes by Aircraft Type

While action is taken on and around airfields to reduce the likelihood of encountering birds, little can be done to assist aircraft while cruising. This responsibility must, therefore, rest with the pilot. The following points, which may help to reduce the possibility or severity of a bird strike, should be kept in mind:

- maintain a good lookout, particularly when flying at low-level;
- be aware that many birds that feed and roost in flocks, may fly between their roosting areas and feeding areas during early morning and evening;
- watch for indications of thermals and updrafts and if possible avoid areas where they may occur. Birds of prey and large water birds tend to soar on rising currents of air and can be encountered at heights up to 20 000 ft AGL;
- avoid flying below 1 500 ft AGL in the vicinity of abattoirs, swamps, wooded hilly areas, garbage dumps or any place that is likely to be attractive to birds;
- it is preferable not to try to avoid a bird by flying under it. It is usually the bird's natural reaction to avoid a collision by diving or side-slipping to lose altitude.

Should a strike appear imminent, try to maintain straight-and-level flight rather than risk control difficul-

ties due to the distortion of the airframe by a bird strike or overstressing of the aircraft by aggressive evasive action. Also, you should try to duck below the line of the instrument panel if there is a possibility that the bird may strike the windscreen.

Aircrews experiencing an en route bird strike should abort the mission and land as soon as possible. While an engine ingestion or a canopy strike may be readily apparent from the cockpit, many fuselage, wing, tail or radome strikes cannot be adequately assessed for damage. Continuing a mission may result in greater structural damage and an emergency situation later in the flight.

Advise ATC, Flight Service or 'all stations,' as appropriate, if you are aware of bird activity on or around an airfield so that other aircraft may be alerted, especially if RPT operations are involved. This is particularly important at large airfields where the control tower may be remote from runway approach and departure paths which might make it difficult for controllers to visually detect smaller flocks of birds.

Avoid, wherever possible, attempting to take off or land when there are birds on or around the runway.

Revise checklist procedures and pre-briefings. When flying low-level routes, higher aircraft speed and greater exposure within the bird's flight environment have led to many damaging and injurious bird strikes. Pilots and

other crewmembers can become involved in cockpit duties which cause them to reduce their lookout. Check-list items should be accomplished in such a manner as to allow for maximum look-out. Briefing bird strikes is much like briefing a take-off emergency where urgency dictates a pre-planned course of action. As a minimum, pilots should brief (or be briefed on) the following:

- potential bird problems along their proposed route of flight;
- wearing the double helmet visor down during daylight hours, the clear visor at night or during low level operations;
- locking shoulder harnesses of injured crewmembers to prevent them from falling forward onto flight controls;
- evasive manoeuvres at low altitude, engine failure procedures if birds are ingested;
- lost cockpit communications including change of aircraft control and aircraft recovery procedures;
- the procedures for a controllability check if the airframe is damaged; and
- crew egress procedures if control cannot be maintained.

The aircrew's ability to react to a bird strike situation is further enhanced by periodically reviewing bird strike procedures during continuation training and safety meetings.

The greatest immediate danger from bird strikes is the loss of aircrew vision from flying glass and debris. *Keep your visor down at all times.*

In 1982, a USAF F-4 pilot was hit in the face by a seagull at 500 kts. He was blinded in one eye and temporarily voiceless but still able to return to base and land. He lived because he flew with his visor lowered.

Report all bird strikes encountered. Apart from being a requirement, accurate bird strike reporting enables the intensity and nature of bird hazards at a particular loca-

tion to be assessed so that action can be taken to control those hazards.

The bird strike problem world-wide parallels our own. Recent message traffic indicates that either bird strikes or bird strike reporting is on the increase. Studies overseas both in Europe and the USA have shown that most bird strikes on high speed low level military aircraft occur between ground level and 300 ft AGL.

A comparison of the average bird strike rate between sorties flown at 250 and 500 ft AGL shows that the average strike rate at 250 ft is approximately four times greater than at 500 ft.

When a 2 kg bird strikes an aircraft travelling at 135 kts, it exerts a 3.8 ton (37.28 kilonewtons) force on a saucer-sized area of the aircraft's frame or engine. If the aircraft is travelling at 270 kts the force is equivalent to 15 tons (147.15 kilonewtons) and at 540 kts, 60 tons (588.6 kilonewtons).

Bird strikes occur during all months of the year; however, there are times of increased bird strikes. Table 1 represents the total number of ADF bird strikes encountered throughout Australia. Due to computer programming difficulties, it is impossible to be specific about why bird strikes occur in some months more than others. Generally speaking, in the north of Australia the wet season begins in December/January. The bird breeding cycle coincides with the 'wet' resulting in larger numbers of birds. The young birds are not good fliers and are not used to aircraft. These factors combine, resulting in more bird strikes. December/January is the RAAF's period of reduced activity therefore fewer strikes occur, but by February, RAAF flying is in full swing which could explain the highest number of strikes in the following months. The reverse is true in winter i.e. cold weather in the south and dry weather in the north reduce bird activity. October/November is usually when major exercises are programmed resulting in higher flying rates and therefore more bird strikes.

Table 2 illustrates the most vulnerable phase of flight to be the cruise/mission, most of which occurred at low-level (0-500 ft) and relatively high speed (greater

	86	87	88	89	90	91	92	93	94	95	96	TOTAL
JANUARY	6	3	10	11	2	5	11	4	1	1	1	55
FEBRUARY	19	14	9	15	16	12	13	13	5	2	1	119
MARCH	7	11	10	15	10	12	10	8	6	6	1	96
APRIL	18	7	8	8	14	9	12	1	4	-	3	85
MAY	13	10	8	17	14	14	5	6	1	3	1	92
JUNE	6	10	6	6	9	7	6	2	-	-	-	52
JULY	15	2	6	6	16	9	10	2	1	-	1	68
AUGUST	3	8	3	8	7	10	4	-	2	1	2	48
SEPTEMBER	12	8	11	6	7	9	1	3	1	2	1	61
OCTOBER	15	9	6	14	12	11	4	1	4	1	2	79
NOVEMBER	15	10	6	20	18	20	3	2	2	1	-	98
DECEMBER	6	5	8	6	12	12	4	1	1	-	1	60
TOTAL	135	101	91	132	137	130	84	44	28	17	14	913

Table 2 - Bird Strikes by Month

	86	87	88	89	90	91	92	93	94	95	96	TOTAL
ON GROUND	1	3	-	1	-	1	1	1	1	-	-	9
TAKEOFF/CLIMB	33	21	27	24	34	32	19	6	6	8	4	214
CRUISE/MISSION	51	49	35	27	37	32	17	29	12	7	6	302
DESCENT/LANDING	33	24	21	59	42	46	38	6	9	2	4	284
UNKNOWN	17	4	8	21	24	19	9	2	-	-	-	104
TOTAL	135	101	91	132	137	130	84	44	28	17	14	913

Table 3 - Bird Strikes by Phase of Flight

than 300 kts). Firstly, because the birds have little warning of the aircraft approaching and, secondly, low-level flight is within the bird's normal environment. The second most vulnerable phase of flight is within the circuit area of our bases (take-off, landing, approach and go-around). Obviously, by reducing the number of birds attracted to an airfield we can effectively reduce the risk of a bird strike. Therefore airfield environments receive the greatest emphasis in attempting to reduce the occurrence of bird strikes.

Table 3 identifies bird strikes by aircraft type and Table 4 shows the number of bird strikes reported at the various ADF airfields. This does not take into account hours flown per bird strike for each aircraft type/group.

Many factors influence the overall bird strike rate in Australia. Some of these are a result of the biology of the bird species involved and the weather patterns at the time. Other factors include the reporting standard of

different units and it is likely that the number of bird strikes has been underestimated, ie, small birds ingested by engines may not leave any evidence.

By continuing to gather information about where and when bird strikes are likely to occur, we can more effectively minimise the hazard caused by birds. As aircraft types and their missions change, as environments alter and people involved with the bird strike hazard are posted, the need for collecting and maintaining bird strike data will remain important.

There are of course variables over which we have no control due to mission requirements. Much of our flying must continue to be carried out at low-level and/or high speeds even though we know that these conditions are conducive to bird strikes. Therefore, it is important that you, the operators, be fully aware of the threat, do all you can to avoid it, and know what to do when you can't avoid it.

	86	87	88	89	90	91	92	93	94	95	96	TOTAL
AMBERLEY	5	3	3	3	2	1	1	-	2	2	-	22
CANBERRA	2	-	-	1	3	2	2	2	-	-	-	12
DARWIN	2	3	3	4	6	1	2	1	-	-	-	22
EAST SALE	4	4	6	2	5	5	1	1	5	-	3	36
EDINBURGH	10	7	1	2	1	6	1	2	-	1	1	32
NOWRA	2	1	1	-	1	-	-	-	-	3	1	9
Oakey	-	-	2	2	-	3	1	-	1	-	-	9
PEARCE	8	7	5	6	5	8	2	-	3	-	1	45
RICHMOND	14	10	13	15	18	21	17	1	-	-	-	109
TINDAL	-	-	-	8	7	-	2	2	1	-	1	21
TOWNSVILLE	7	1	1	2	4	-	2	-	1	-	-	18
WILLIAMTOWN	1	5	6	1	2	4	6	-	2	3	-	30
TOTAL	55	41	41	46	54	51	37	9	15	9	7	365

Table 4 - Bird Strikes by ADF Airfields

A LUCKY CREW!

Whilst it's generally true that the faster an aircraft is flying the more serious the damage from a bird strike, relatively slow bird encounters can still cause considerable damage with attendant risk of serious crew injury.

Recently a Twin Otter was descending through cloud 15 nm south of Newcastle, NSW when, at an altitude of 1200 ft and 120 kts (ie, at approximately Caribou speed), it suffered a bird strike. The windscreen was punctured on the right side, slightly injuring the copilot. The captain declared a PAN and requested an ambulance meet the aircraft on arrival. The aircraft subsequently landed without further incident.

The bird that caused the damage and injury appeared to have been the size of a Swift, yet made a hole in the windscreen of about 37 x 29 cm.

TRAGEDY AT ELMENDORF



On 22 September 1995, geese brought down a USAF E-3B AWACS aircraft shortly after lift-off, killing all on board.

The following account of the accident has been extracted from a report published in the US Flight Safety Foundation magazine *Accident Prevention*. This report, in turn, was prepared from the USAF Aircraft Accident Investigation Report: *E-3B Aircraft No 77-0354, Assigned to 3rd Wing, Elmendorf AFB, Alaska, 22 September 1995*.

The crew of a U.S. Air Force E-3B, a modified Boeing 707 equipped with sophisticated airborne warning and control systems (AWACS), was holding short of Rwy 5 at Elmendorf Air Force Base (AFB), Alaska. As the crew waited for take-off clearance, a C-130 Hercules that was departing Rwy 5 disturbed a flock of Canada geese that were roosting in the infield adjacent to the runway. A controller in the Elmendorf control tower saw the geese become airborne but did not notify the E-3 crew or Elmendorf airfield management.

The E-3 (call sign *Yukla 27*) was cleared into position on Rwy 5. Approximately two minutes after the C-130 had departed, *Yukla 27* was cleared for take-off at 0745:30 hrs local time and the crew began the take-off roll. As the aircraft rotated for lift-off, the senior tower controller observed geese take flight and turn directly into the path of the E-3. Numerous birds were ingested into the aircraft's No 1 and No 2 engines, resulting in a catastrophic failure of No 2 engine and compressor stalls in No 1 engine.

At 0746:43, the copilot radioed, '*Elmendorf tower, Yukla 27 heavy has an emergency. Lost No 2 engine, we've taken some birds*'. Witnesses then observed the aircraft enter a slow, climbing turn to the left. Six seconds later, the captain called for the dumping of fuel. Shortly after, the stick shaker activated and stayed on for the remainder of the flight.

At 0746:56, the copilot radioed, '*Yukla 27 heavy's coming back around for an emergency return*'. Ten seconds later, the copilot radioed, '*27 heavy, emergency*'. This was followed shortly by a transmission on the tower frequency, '*Roll the crash, roll the crash*'.

At 0747:11, the AWACS captain said, '*We're going down*'. The aircraft impacted a hilly, wooded area on the

base, less than 1 nm from the departure end of the runway (Figure 1). The aircraft broke up, exploded and burned. All 24 crewmembers were killed in the accident.

The USAF accident investigation report concluded that the accident was directly caused by the ingestion of Canada geese into No 1 and No 2 engines. Furthermore, two factors substantially contributed to the accident. First, the [3rd] Wing lacked an aggressive program to detect and deter geese; specifically, the Bird Hazard Reduction Working Group (BHRWG) did not adequately prepare for the migration season, airfield management's efforts to detect and deter geese were inadequate and an earlier safety agency Staff Assistance Visit (SAV) had [misted] the Wing to believe that [the Wing] was prepared. Second, the tower controller failed to notify the [accident] aircraft or airfield management that geese were present in the infield.

The ingestion of the geese into the aircraft's engines caused a loss of thrust that rendered this aircraft incapable of controlled flight. The accident flight was a scheduled 6.2 hr routine training mission. The accident occurred during twilight and in VMC. Weather was not a factor in the accident; sunrise on the day of the accident was 0742.

Engine damage

All four engines on the accident aircraft were recovered and examined. No 1 engine was found to have experienced a bird strike (one major-size hit and two minor size hits) seconds after rotation. Within four seconds the engine was operating at diminished power (approximately 50 per cent of take-off power). It then stalled four or five times and struck a tree upstream of the initial engine ground scar.

No 2 engine was found to have experienced a bird strike (three major-size hits) seconds after rotation. Within eight seconds this engine lost enough first-stage fan blades to severely damage and then fragment the IGV [inlet guide vanes] case. The nose cowl was then free, and flipped up over the wing and departed the aircraft. Then the engine either fell to a 'hung' operating condition or flamed-out and windmilled to ground impact.

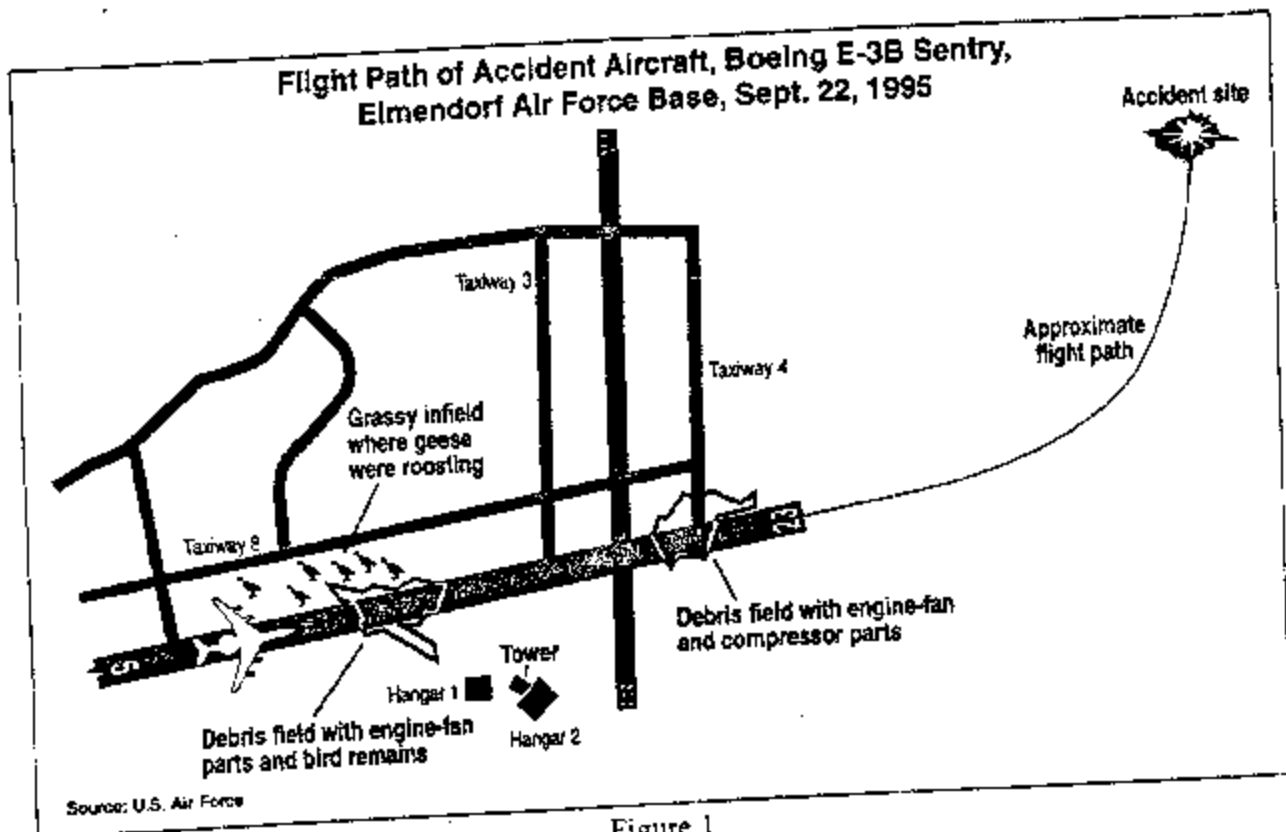


Figure 1

There was no evidence to suggest that either No 3 or No 4 engines had experienced a bird strike. Both engines continued operating at take-off conditions until being pressed to a higher thrust condition by the crew within eight seconds after bird strikes on the two left engines. This operating condition continued until ground impact.

FDR/CVR

Because of the limited FDR data, investigators were able to determine only the following about the accident flight:

- the aircraft lost power on No 1 and No 2 engines within six seconds after rotation;
- the aircraft was airborne for approximately 42 seconds after take-off and 37-39 seconds after losing power to the engines; and
- the maximum altitude the aircraft achieved above the runway elevation was approximately 250 ft.

The local bird problem

Investigators reviewed the USAF regulations and the threat of bird/aircraft strikes at Elmendorf AFB. Air Force Regulation [AFR] 127-15, The Bird Aircraft Strike Hazard (BASH) Reduction Program, gives policy and guidance for implementing an effective bird-aircraft-strike hazard-reduction program. It designates the USAF agencies that are responsible for carrying out the program and evaluating its effectiveness. It outlines

procedures for developing a Wing-level BASH program and establishes requirements for its operation.

USAF personnel have counted the goose population at Elmendorf AFB since 1990 which has increased from 1 000 geese in 1990 to 2 700 geese in 1995. On the day of the accident, there were approximately 900 geese on the base, the report said.

In reviewing safety data, investigators found that the only recorded incident of geese striking an aircraft at Elmendorf occurred in September 1993, when a C-130 aircraft struck several geese on the runway after landing.

During a two-week period preceding the accident flight, Elmendorf base operations and wild-life personnel had dispersed geese from the infield areas of Rwy 5 and Rwy 33 on several occasions. Clearly, 3rd Wing was on notice that geese were indeed locating in infields as well as on hard surfaces such as runways and taxiways, the report said. On two occasions, conservation personnel had to kill geese with shotguns in order to disperse the flock. The geese were beginning to establish themselves and occasional dispersal was not deterring them from returning.

Investigators reviewed the efforts of the BHRWG at Elmendorf as required by USAF regulations. The BHRWG did not formulate a concrete plan to deal with changing bird activity levels or the presence of geese in the airfield, the report said. 3rd Wing had an effective OPLAN [operations plan], but the BHRWG was responsible for ensuring that the implementation of this plan resulted in effective geese detection and deterrence at all times of the year. The efforts of Elmendorf airfield

management personnel to detect and deter geese were reviewed. Roosting infield geese went undetected because airfield management had no controlling plan to locate them, the report said. It was evident that personnel knew geese posed a danger to aircraft, and they acted to disperse them on several occasions; but their efforts to detect or deter infield geese were inadequate. Few, if any, of the suggested patrol and deterrent methods suggested by AFR 127-15 were in place, the report said.

The report noted that airfield management did not sufficiently check these infield areas for the presence of geese. Base operations personnel and supervisors of flying [SOF] were engaged in little other than vehicle sweeps of runways and taxiways. A cursory glance at the infield would not result in the detection of geese. These patrols were effective, if at all, during daylight hours only. Prior to the accident, there was no illumination of infield areas before first light. The report noted that the last runway check occurred nearly 3.5 hrs before the accident aircraft began its take-off roll.

Investigators found that the worst possible combination of circumstances existed: there were infrequent patrols of the airfield, almost no checking of infields and no placement of static deterrents. Those aircraft that began their take-off roll at or before dawn were at risk that geese would move into their flight path, as happened in this accident.

An Air Force BASH Team conducted an SAV at Elmendorf AFB in July 1995 when the goose population was low, the report said. This team emphasized habitat management but did not discuss the particulars of the 3rd Wing's plan for migration season. The team did advise airfield management personnel to prevent geese from establishing themselves in the airfield.

The Elmendorf AFB airfield manager was interviewed during the investigation. She was well aware of the BASH plan and had been personally briefed by the BASH team during the July 1995 visit. The investigating officer attempted to establish her understanding of airfield management's specific responsibilities in the OPLAN, but she invoked her right to remain silent.

The investigating officer interviewed the senior tower controller and another controller who were on duty in Elmendorf tower at the time of the accident. Both controllers, who had an excellent view of the runway area, invoked their rights to remain silent, the report said. Witnesses told investigators that after the accident, the senior tower controller said he observed geese lift off and turn right, directly into the path of the [accident] aircraft.

Moments before the aircraft's departure, the senior tower controller witnessed a C-130 take off and flush a flock of geese from the infield adjacent to Rwy 5, the report said. Fortunately for that aircraft, this flock turned away from its flight path.

The report noted that while the senior tower controller could have assumed that every infield goose joined the flock that the C-130 flushed and that this flock had left the area, sound judgment dictates that he should have

contacted the E-3 and warned the crew. The aircraft could have held take-off until the squadron SOF or base operations could ensure that these geese had not returned and that no more geese were in the area. The investigating officer could not understand why the controller did nothing. He had more than two minutes to advise the [accident] aircraft that a flock of geese had taken wing and nearly struck the C-130.

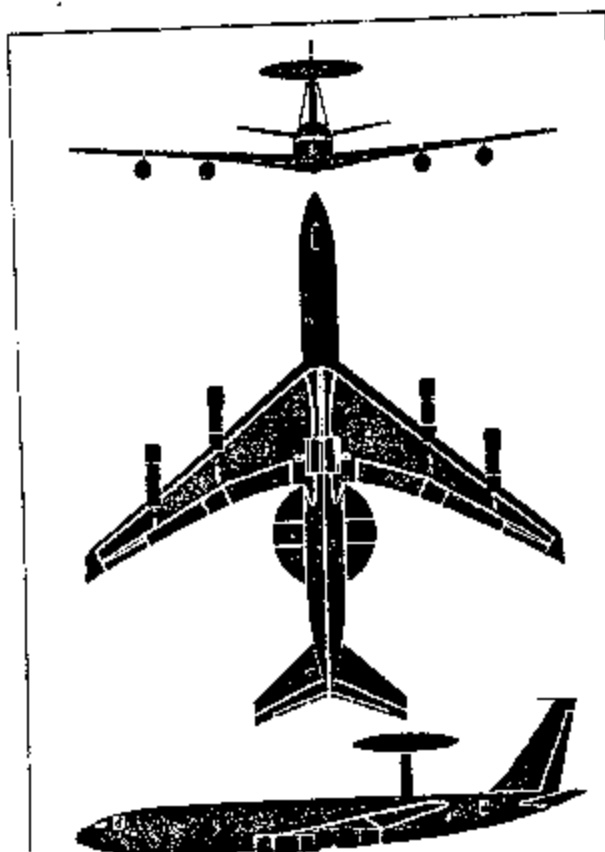
The investigating officer commented in the report that he believed the tower controller had a duty to warn the accident aircraft and that his failure to do so was a contributing factor to this accident. While it would not have been SOP for a tower controller to raise the bird watch condition [BWC] to severe, he certainly could have warned the aircraft of the potential hazard.

Post-accident actions

The following new procedures were ordered after the accident:

1. When workload permits, controllers will use binoculars to visually scan the runway and infield environments for concentrations of birds or bird activity prior to issuing a takeoff or landing clearance.
2. Airfield management will conduct an airfield inspection 30 minutes prior to civil twilight. This inspection should focus on the current bird activity and should help anticipate the increase in bird activity that is normally associated with the early morning period.
3. Airfield management will conduct an airfield inspection within 30 minutes of the first departure of each day.
4. The SOF, airfield management, and ATC watch supervisor (WS) all have the authority to increase the declared BWC in the interest of flight safety. In the absence of a Wing SOF, airfield management will have the authority to decrease the BWC.
5. In the absence of the SOF and when the tower watch supervisor and/or airfield management deems it necessary, he/she may increase the BWC. When the ATC WS upgrades the BWC, he/she will notify airfield management as to the location of the birds.
6. The SOF and the ATC WS may restrict and/or modify air traffic operations as deemed necessary for flight safety (eg, cancellation of practice approaches, full stops only).
7. If bird dispersal is required on the airfield, the BWC will automatically be upgraded to severe during such activity.

The report noted that the new procedures required that the BWC be declared if there are birds flying over or on the ground anywhere close to the runways (infield, edges, taxiways, ramps, etc) because they need to be dispersed. Most severe bird conditions, which prohibit take-offs and all but emergency and fuel-related diversionary landings, can be resolved within 5-15 minutes.



Boeing E-3B Sentry

The E-3B Sentry airborne warning and control systems (AWACS) is a mobile, jamming-resistant high-capacity radar station and command, control and communications centre installed on a Boeing 707 airframe.

The first development aircraft, known as the EC-137, first flew in 1972. The E-3B has a basic operational crew of 20, including four flight crewmembers and 16 AWACS specialists, although this number can vary depending on the mission.

The aircraft has a maximum take-off weight of 147 417 kg (325 000 lb), a service ceiling of 29 000 ft and a maximum level speed of 460 kts. It has an endurance on station of 870 nm (1 610 km), six hours from base, and a maximum unrefuelled endurance of 11 hrs.

Source: Jane's All the World's Aircraft.

The aftermath

Four 3rd Wing officers received disciplinary action for their lack of leadership before the fatal crash of the E-3B Sentry AWACS aircraft.

The officers were disciplined for failing to provide leadership to reduce bird hazards at the base airfield before the 22 September crash in which 24 people were killed.

One officer received a letter of reprimand and was relieved as vice commander of the 3rd Wing. He was the

former chairman of the wing bird hazard reduction working group. The names and punishments of the three other officers were not released because of Privacy Act restrictions.

Copies of the accident report were given to commanders outside 11th Air Force — headquartered at Elmendorf — for their review and possible action against other people involved in the operation and evaluation of the wing bird strike hazard program. As a result, administrative action has been started against an additional officer whose name and the action initiated are also protected by the Privacy Act.

The accident investigation board determined that the crash was caused by a flock of Canada geese striking the aircraft as it was taking off. Several geese were ingested into the No 1 and No 2 engines which failed, causing the plane to crash into a wooded area about a mile from the base. The jet, assigned to the 962nd Airborne Air Control Squadron, was the first AWACS aircraft to crash.

The officer in charge of administrative actions was quoted as saying that, 'Military service is an inherently dangerous undertaking, [but the] Air Force strives to reduce that inherent risk in all activities, especially military flight operations'.

He added that, 'The risk from bird hazards encountered by Yukla 27 the day it crashed could have been reduced if appropriate actions had been taken and guidance had been given by the other officers responsible for implementing the wing bird avoidance program'.

The accident investigation provided sufficient facts for the investigator to arrive at his opinion as to the cause of the accident, said Wing officials. The administrative officer subsequently directed a criminal investigation by the Air Force Office of Special Investigation to fully develop issues identified by the accident investigator. That criminal investigation expanded on areas that were not within the charter of the accident investigator. He elected not to take action against control tower workers at the time of the accident based upon that report. And examination of the regulatory guidance for the Elmendorf airfield management workers revealed that they were meeting the basic requirements established by local and higher headquarters directives.

He added, 'As the investigation showed, at the time of the incident, 3rd Wing people were taking steps to react to geese they saw on the airfield; however, they were not taking adequate steps to detect and deter geese from appearing on or near the airfield.'

'Since the incident, they have completed a thorough review of their bird avoidance plan, revising it to more aggressively reduce the risk of bird strikes.'

'In addition, as we approach the bird migration season, all our Alaska military organisations are reviewing their bird avoidance programs and coordinating those efforts with civilian airport representatives and state officials'.

BIRDS AND BEDLAM

BIRDS are beating up aircraft badly and recent history suggests that they may be winning the world-wide air war. For example, the Israeli Air Force has lost more aircraft to birds than in war. In Europe and Israel, more than 168 military aircraft have been confirmed lost to bird strikes since 1950. Are the birds winning the war in the sky?

The following is a selected list of significant bird strikes to civil and military aircraft. The reports have been compiled from various research reports and government accident records. Sources include *Flight International* magazine, the US National Transportation Safety Board, the UK Civil Aviation Authority, and BAE.

All fatal and hull loss events involving large commercial jet aircraft are included. Fatal and serious damage events involving small general aviation aircraft are excluded.

Large commercial jets — overseas

1. 18 May 1996. A B747 lost one engine to a bird strike on take-off from Lester B. Pearson International Airport and dumped thousands of pounds of fuel over Lake Ontario before returning for a precautionary landing.

2. 30 March 1996. A B767 lost one engine on take-off from Vancouver International Airport after striking a flock of ducks. The aircraft returned to the airport for a precautionary landing after dumping fuel over the ocean. Damage: \$2 million plus.

3. 10 December 1995. On a night approach to JFK International, a B747 struck geese at 7 500 ft AGL. The crew saw a flash of white before being struck by what felt like sandbags. The impact destroyed two engines and extensively damaged the airframe. Repairs cost approximately \$6 million.

4. 18 September 1995. An A320, landing at LaGuardia Airport, struck Canada geese. Engine and airframe damage totalled \$2 million. Loss of service added another \$500 000.

5. 3 June 1995. A Concorde, on final approach to JFK International Airport, struck a large number of geese. After the emergency landing, all passengers evacuated safely, but the geese had destroyed No 3 and No 4 engines. Damage: \$6 million.

6. 25 July 1990. Ethiopian Airlines 707-300, Addis Ababa, Ethiopia. During take-off, the crew spotted birds on the runway prior to take-off decision speed but chose to continue the take-off. The aircraft ingested one or more pigeons into at least two engines. The crew rejected the take-off, but were unable to stop on the runway. The aircraft struck light towers and was destroyed by a subsequent fire. One of the four crew on this cargo flight was seriously injured.

7. 15 September 1988. Ethiopian Airlines 737-200, Bahar Dar, Ethiopia. During take-off, the aircraft ingested numerous pigeons into both engines. One engine lost thrust almost immediately and the second lost thrust during the emergency return to the airport. As a result of the crash landing, 31 of the 105 passengers were killed.

8. 29 September 1986. Indian Airlines A300, Madras, India. At about rotation speed during take-off, the aircraft ingested at least one bird into the right engine. The engine lost thrust and although the aircraft was capable of continuing the take-off, the crew decided to reject the take-off and overran the runway. The aircraft was declared a hull loss. None of the 185 passengers and 17 crew was seriously injured.

9. 4 April 1978. Sabena 737-200, Gosselies, Belgium. During a touch-and-go landing during a training flight, the aircraft struck a flock of pigeons. At least one was ingested into No 1 engine, which caused some loss of engine thrust. Although the aircraft had enough power to continue the take-off, one crewmember initiated a rejected take-off while the other crewmember attempted to continue the take-off. The aircraft overran the runway and was destroyed by a post-crash fire. The three crewmembers were not seriously injured.

10. 12 November 1975. Overseas National Airways DC10-30, JFK Airport, New York. During the take-off roll, the aircraft struck seagulls and the take-off was rejected. The right engine had an uncontained failure and

the aircraft overran the runway. The aircraft was destroyed by a subsequent fire, but none of the 128 passengers and 11 crew was seriously injured.

Large commercial jets - Australia

1. 1 January 1996: Boeing 747-200, Cairns, Qld. On take-off the aircraft struck several large birds destroying two of its four engines.
2. 4 September 1987: Airbus A300-203, Cairns, Qld. As the aircraft was taking off birds were ingested in one engine. The aircraft returned and landed. An engine change was required.
3. 19 July 1986: Boeing 767-238, Brisbane, Qld. Passing 200 ft on climb-out the aircraft struck several birds. The left engine was shut down due to vibrations. The aircraft dumped fuel and returned for landing at Brisbane.
4. 5 April 1983: Boeing 747, Avalon, Vic. The aircraft struck a bird during a training flight causing severe damage to one engine. The engine was shut down due to the severe vibration and the aircraft returned to Melbourne.
5. 11 July 1982: Boeing 747, Melbourne, Vic. On initial climb-out the aircraft struck a flock of birds. No 3 engine failed and was shut down. No 4 engine was subject to vibration and a power reduction was made. The aircraft returned for landing at Melbourne. Both engines were extensively damaged.
6. 30 April 1973: Boeing 747-238, Sydney, NSW. During take-off the aircraft suffered a multiple bird strike involving 12 silver gulls. Almost immediately there was severe vibration in No 3 engine and indications of overheating in No 4 engine. No 4 engine subsequently recovered and No 3 engine was shut down due to the vibrations. The vibration in No 3 engine was caused by the failure of a fan blade which pierced the nacelle, struck the runway and rebounded into the horizontal tail section. The aircraft returned for landing at Sydney. Both engines were badly damaged.
7. 16 December 1972: DC8-50, Sydney, NSW. During the take-off roll the aircraft encountered birds at V2. A small fire, observed to have been started by flame from one of the aircraft engines, occurred in grass adjacent to the runway immediately after take-off. The No 4 engine was shut down and the aircraft returned for landing after dumping fuel. The No 4 engine was extensively damaged.
8. 25 January 1970: DC9-30, Sydney, NSW. Passing approximately 150 ft on departure the aircraft struck a flock of birds. The starboard engine lost power and

began to vibrate. The engine was shut down and the aircraft returned to Sydney.

9. 1 December 1969: Boeing 747-321B, Sydney, NSW. During the take-off roll the aircraft struck a flock of Gulls. No 2 engine lost power and the captain decided to abort the take-off at V1. The aircraft overran the runway end and came to a rest in the soft earth. No injuries were sustained by the passengers or crew. The aircraft suffered only minor damage in the bird strike, but was substantially damaged in the overrun.

Other commercial aircraft — overseas

1. 25 September 1995: A Cessna Citation carrying Newt Gingrich, Speaker of the U.S. House of Representatives, struck geese on take-off from Mackinac Island. The pilot aborted the take-off but couldn't keep the aircraft on the runway. Luckily, nobody was hurt.
2. 20 January 1995: Dassault Falcon 20, Le Bourget Airport, Paris. Just after rotation, the aircraft struck at least 15 lapwings. The left engine ingested more than one bird and had an uncontained failure, but the pilot was able to continue the take-off. However, the aircraft caught fire and crashed while the pilot was attempting a return to the airport.
3. 20 January 1994: A Falcon 20 departing Le Bourget struck lapwings causing an uncontained engine failure and a fiery crash killing 10 people.
4. 25 January 1992: Cessna 401, Maasi-Mara, Kenya. While in cruise, the aircraft struck a bird suspected to be a Marabou stork weighing about 13 lb (5.9 kg). The impact caused separation of a wing tip fuel tank and aileron. All seven passengers and crew were killed.
5. 26 December 1991: Piper PA31, Maasi-Mara, Kenya. A 12 lb (5.4 kg) white-headed vulture struck the aircraft and penetrated the windshield at about 250 ft. The aircraft lost control and crashed, killing all nine passengers and crew.
6. 7 April 1981: Lear 23, Cincinnati, OH. At 4 000 ft, a loon estimated at 8 lb (3.7 kg) penetrated the right windscreen, killing the copilot and injuring the pilot. No 2 engine and the hydraulic and brake systems were also lost.
7. 20 November 1975: HS125 Viper, Duxford, UK. The aircraft ingested lapwings into both engines during initial climb. The aircraft lost power and crashed and caught fire just past the end of the runway. The nine



aircraft occupants escaped, but six occupants in a car hit by the aircraft were killed.

8. 26 March 1973: Lear 24, Atlanta, Ga. Both engines ingested multiple cowbirds immediately after take-off, with about 14 striking the left engine and at least five striking the right engine. The aircraft crashed, killing all seven passengers and crew and injuring one person on the ground.

9. 23 November 1962: Viscount, Maryland, USA. At night, at 6 000 ft, the aircraft struck a flock of whistling swans. One, estimated to be 13 lb (6 kg) penetrated the tail plane leading edge, weakening the structure, and causing the tail plane to detach. The aircraft crashed, killing all 17 passengers and crew.

10. 15 July 1962: DC-3, Lahore, Pakistan. The copilot was killed after a vulture penetrated the windshield during cruise. The other two occupants survived.

11. 4 October 1960: Electra 188, Boston, Mass. Shortly after becoming airborne the aircraft ingested starlings into three of its four engines. No 1 engine was shut down and Nos 2 and 4 engines lost power. The aircraft stalled and crashed into Boston Harbour, killing 62 of the 72 passengers and crew. This is the greatest loss of life due to a bird strike.

Other commercial aircraft – Australia

1. 24 November 1987: Pereira Osprey 2, Cape Liptrap, Vic. At a height of about 50 ft on initial climb the aircraft suffered a bird strike which resulted in the canopy being broken. Although the pilot's vision was restricted by the slipstream, he was able to land the aircraft. After shutting down the engine the pilot discovered that the aircraft was on fire. He vacated the aircraft and it was totally consumed by the fire.

2. 18 November 1985: Piper PA-36-375, Benerembah, NSW. The pilot was carrying out the first spray run of a paddock when, towards the end of the run, he was distracted by a large flock of birds flying up in front of the aircraft. An attempt was made to fly under the flock and the aircraft struck power lines. The main undercarriage snagged the line and wire cutters fitted to the undercarriage did not cut the wires. The aircraft impacted the ground 82 metres from the power lines.

3. 19 July 1985: Gates 35A, Sydney, NSW. The aircraft was flaring to land at 50-100 ft at night when it struck a flock of gulls. Both engines ingested birds and were severely damaged, causing the aircraft to land without power.

4. August 1982: Piper Aztec, En route Blackwater to Emerald, Qld. The aircraft was cruising at 2 500 ft on autopilot when it suffered a bird strike. There was a loud explosion and the pilot found himself lying across the right seat and bleeding from the head. He also discovered that his right hand was severely lacerated. In spite of his impeded vision from one eye, he managed to land safely at Emerald.

5. 7 April 1982: Cessna 310, Fogg Bay, NT. The aircraft was conducting prawn spotting operations at 650-700 ft when it struck a frigate bird. The bird penetrated the windscreen and hit the occupant of the right front seat. The passenger received minor cuts and bruises. The aircraft landed safely at Darwin.

Large military aircraft

1. 15 July 1996: Belgian Air Force Lockheed C-130, Eindhoven, Netherlands. The aircraft struck a flock of birds during approach and crashed short of the runway. All four crewmembers and 30 of the 37 passengers were killed.

2. 14 July 1996: NATO E-3 AWACS, Aktion, Greece. The aircraft struck a flock of birds during take-off. The crew aborted the take-off and the aircraft overran the runway. Although none of the crew was seriously injured, the aircraft was beyond repair.

3. 22 September 1995: USAF E-3 AWACS, Elmendorf AFB, Alaska. During take-off, as the aircraft was passing rotation speed, the aircraft struck about three dozen geese, ingesting at least three into No 2 engine and at least one into No 1 engine. The aircraft was unable to maintain controlled flight and crashed in a forest about 1.6 km beyond the runway. All 24 occupants were killed. Added to the tragic loss of life, dollar costs reached \$189 million.

4. September 1987: USAF B-1B, Colorado, USA. Aircraft lost control and crashed after a large bird struck the wing root area and damaged an hydraulic system. The aircraft was on a low-level, high speed training mission. Only three of the six occupants were able to successfully bail out.

5. 1980: Royal Air Force Nimrod, Kinloss, Scotland. Aircraft lost control and crashed after ingesting a number of birds into multiple engines.

What do all these statistics mean?

Large birds are the greatest threat to aircraft. The force of impact depends on the bird's weight and the aircraft's speed. A large number of heavy birds striking an aircraft travelling at high speed can exceed the design limits of its airframe and engines.

Most of today's engines are designed to absorb a 1.5 lb bird volley, although early designs and smaller engines were not built to this standard. The latest generation of high bypass ratio turbofan engines are required to withstand a 2.5 lb bird volley, but their larger intake areas and reduced noise means they are struck more frequently.

Bird strike reports help engine and airframe manufacturers improve designs, and airport operators make environment management decisions. The bird hazard is serious. As a pilot, you have a vital role to play by reporting birds and bird strikes, and if you see birds near the runway, you may want to postpone your take-off decision until the birds are dispersed.

BIRD STRIKE:

DHC DASH 8 VH-JSI

BROOME, WA, 17 May 1996

(Extracted from Bureau of Air Safety Investigation (BASI) Report 9601590)

THE de Havilland Dash 8 with a crew of three and 14 passengers was passing 4 800 ft on descent to Broome at 243 kts when it struck a wedge-tailed eagle. The bird impacted the leading edge at the root of the left wing. The wing-to-fuselage fairing was punctured and the forward wing spar and the electrical components attached to the spar were damaged.

The left engine instrumentation failed and the master caution panel indicated multiple systems failures. The crew shut down the left engine 2 minutes and 9 seconds after the bird strike when the aircraft was passing through 1 860 ft at a speed of 220 kts.

The left main landing gear unsafe warning light illuminated when the landing gear was extended. The crew discontinued the landing approach and elected to hold between 5 nm and 10 nm northwest of the aerodrome while they checked the aircraft systems. Thirty-seven minutes after the bird strike, the aircraft was landed on Rwy 10. During the latter part of the landing roll, the aircraft captain was unable to maintain directional control through the nose wheel steering. He attempted to slow the aircraft using reverse thrust on the right engine and the normal brakes, but the brakes failed. The aircraft veered off the sealed runway to the right before the pilot stopped it, using the emergency brake system.

Damage to the aircraft

BASI's investigation team was unable to inspect the aircraft in the as-damaged condition. The manufacturer's personnel supervising the repair of another Dash 8 aircraft, together with the operator's engineers, had commenced disassembly of the aircraft before the investigator arrived at Broome. This action precluded a methodical recording of damage and assessment of the effects of the bird strike on the aircraft by the investigation team.

The wiring looms routed along the leading edge of the wing between the left engine nacelle were significantly damaged. At least 30 of the single or twisted pair wires from this area, as well as one of the two main electrical power cables, had been severed during the

impact. Maintenance engineers reported that all the wires in the looms routed along the wing inboard leading edge had been severed or stretched. Wires had also pulled from their respective multi-pin connectors, and whole connectors had been ripped from their airframe mounted counterpart.

The wiring for the attitude and heading reference system and the weight-on-wheels was routed on the forward face of the wing spar. Damage to the attitude and heading reference system wiring rendered the flux valve ineffective and caused the attitude and heading reference system to revert to directional gyro mode.

The wing front spar assembly and the wing lift tie strap sustained structural damage. The wing spar web was permanently bowed aft approximately 3 mm, and the lower spar cap forward flange was cracked. The wing lift tie was also deformed, with several solid rivets sheared. The composite wing-to-fuselage fairing and its supporting rib assembly were destroyed by impact forces.

System description

Engine instruments. Each engine instrument has a dedicated signal path from its source. The signal path is routed via the same electrical loom carrying the weight-on-wheels wiring on the forward face of the wing spar. The indicator generates both the digital and analogue displays as well as the 0-5 volt DC output to the digital flight data recorder.

The left engine RPM and torque instruments and the propeller RPM instrument were inspected and bench tested. The instruments were found to be capable of operating within specified tolerances and they complied with airworthiness directive AD/INST/9 AMDT 5. The signal path from each instrument to the flight data recorder was serviceable and test signals corresponded to the instrument indications throughout each instrument's range.

No reason could be found for the loss of engine instrument indications without a loss of digital flight data recorder data. The manufacturer of the aircraft and

the engine instrument supplier are continuing to research this aspect.

Landing gear, brakes and nose-wheel steering

The aircraft is fitted with a proximity switch electronic unit which utilises inputs from proximity sensors and micro switches to operate indicators in the landing gear extension and retraction system to verify uplock and downlock conditions.

The landing gear has a warning horn which is activated by the proximity switch electronic unit at a steady 2 000 Hz tone whenever the following conditions exist:

- landing gear not down and locked, flaps selected to 15° or greater, auto-feather system deactivated, and power levers below take-off setting; and
- landing gear not down and locked, one or both power levers at or near flight idle, and indicated airspeed below 130 kts.

The proximity switch electronic unit also provides weight-on-wheels and gear position information to systems such as spoilers, auto-feather, auto-flight control and stall warning, and operates a warning horn and provides warning information if certain doors are not properly closed. The wires to these systems are contained within co-located wiring looms which were severed or disconnected during the impact.

For nose wheel steering to operate, a valid weight-on-wheels signal must be received by the proximity switch electronic unit.

To work normally the brake system also requires valid weight-on-wheels and wheel transducer signals.

Weight-on-wheels information is supplied to the proximity switch electronic unit by dual proximity sensors incorporated on each landing gear. These sensors and redundant circuits ensure the proximity switch electronic unit has continued valid weight-on-wheels information in the event of failure of one sensor or circuit. Warning of such a failure is indicated by illumination of the weight-on-wheels caution light. Signals from these weight-on-wheels sensors are transmitted through wiring routed through two co-located looms and connectors.

In this occurrence the severing and disconnection of wires in the looms and the connectors at the fuselage resulted in a failure of both left weight-on wheels signals to reach the proximity switch electronic unit.

As a result the nose wheel steering, anti-skid braking, and ground spoiler deployment systems were rendered inoperative. The loss of the anti-skid system also rendered the normal brakes inoperative.

Bird information

Examination of the remains of the wedge-tailed eagle by an amateur ornithologist placed its weight at approximately 10 kg (22 lb). The bird had the undigested carcass of a rabbit-sized animal in its gut.

Bird strike design requirements

The aircraft was manufactured to comply with US Federal Aviation Regulation (FAA) 25 design criteria covering transport category aircraft. A search of the regulation failed to highlight any section dealing exclusively with bird-strike design criteria for wing components. However, Amendment 25-23 to Federal Aviation Regulation 25 states:

One of the comments recommended that both the windshield and the wing should be included in the bird strike criteria of Section 25.631. Moreover, it was suggested that the use of an eight-pound bird in this requirement may not be realistic and that a larger sized bird should be considered. Other comments suggested that only smaller sized birds be considered. The Federal Aviation Administration does not agree that the wing and windshield should be included in this proposal. Service experience has not shown that the current windshield strength requirements for bird strikes in Section 25.775 are inadequate or that a special investigation of wing structures for resistance to bird strikes is necessary. Moreover, the bird strike records indicate that encounters with birds weighing more than eight pounds are a rarity and that on the basis of probability, eight pounds is a reasonable value.

This amendment explains that, based on service experience, the US FAA was not prepared to amend their current design criteria for windshields and wings to include birds weighing more than 8 lb. Consequently, the wing-to-fuselage fairing was not designed, nor was it required to be designed, to enable the structure beneath it to withstand a bird weighing 22 lb.

Structural damage to the aircraft was significant. However, within the framework of Federal Aviation Regulation 25, impact with such a massive bird at high speed was not contemplated.

The investigation determined that the damage to the wiring looms attached to the forward face of the left wing forward spar caused a failure of at least the left engine instrument systems, the left landing gear weight-on-wheels system to the proximity switch electronic unit, and the left attitude and heading reference system.

Findings

1. System redundancy was compromised when the wiring was damaged, resulting in the failure of the left weight-on-wheels signal to the proximity switch electronic unit.
2. The nose wheel steering, anti-skid and normal braking, and ground spoiler deployment systems were rendered inoperative.
3. The aircraft was manufactured to comply with US Federal Aviation Regulation 25 design criteria covering

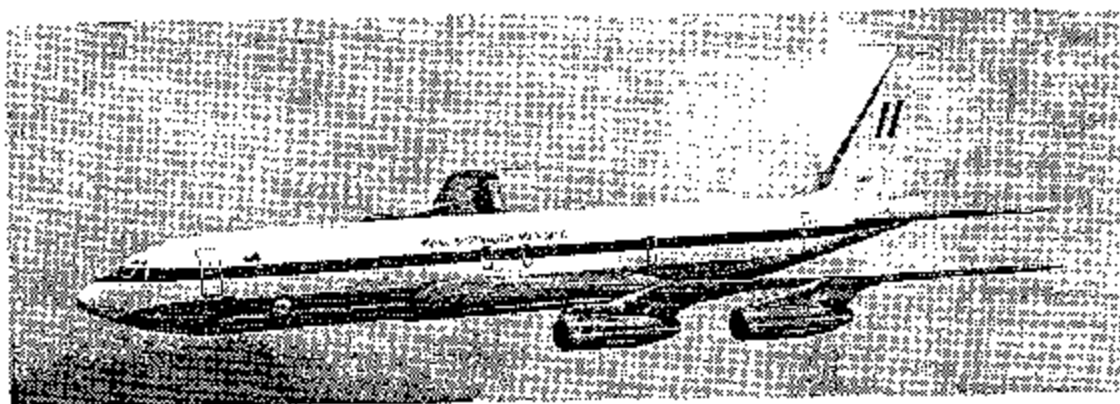
transport category aircraft. Consequently, the wing-to-fuselage fairing was not designed, nor was it required to be designed, to protect the structure beneath it from impact with a bird weighing 10 kg.

Significant factors

1. The aircraft struck a 10 kg wedge-tailed eagle.
2. The left engine instrumentation failed and the master caution panel indicated multiple system failures.

3. System redundancy was compromised when the wiring was damaged, resulting in the failure of the left weight-on-wheels signal to the proximity switch electronic unit.

4. The nose wheel steering, anti-skid and normal braking, and ground spoiler deployment systems were rendered inoperative. →



THE INCIDENTAL COSTS OF BIRD STRIKES

The incidents and accidents discussed in this edition of *Focus* help to bring home the seriousness of such events when bird and aircraft meet unexpectedly in midair. But it is worth pausing to also consider the less serious, but nevertheless potentially expensive, aspects of such encounters.

In June one of our Boeing 707s suffered an apparent bird strike just after rotation during departure from Richmond. The crew heard a loud bang which was accompanied by the aircraft yawing slightly to the right. The take-off was continued and the flight engineer confirmed a minor power loss and subsequent recovery coincident with the noise heard. Shortly after Tower advised that they had observed a flame from the rear of No 4 engine. Suspecting a bird strike, the crew levelled the aircraft at 1 500 ft and initiated appropriate checklist actions.

Remaining within the Richmond control zone, the decision was taken to climb to 8 000 ft and commence fuel dumping prior to landing back at Richmond. The aircraft subsequently landed without further incident. A maintenance inspection disclosed only minor damage to one blade of the first stage compressor — well within tolerance. The aircraft's No 4 engine most probably ingested one small bird.

So far, so good? Not quite, the estimated aircraft take-off weight was 250 000 lb and a fuel dump down to 220 000 lb was necessary prior to landing. In addition to the undesirability of dumping some 30 000 lb (or almost 14 tonnes) of aviation kerosene into the lower atmosphere, some of which may possibly have drifted to earth, an economic loss of the kerosene, paid for by the taxpayer, was incurred.

The crew did everything right in the circumstances, and in a similar situation in the future the same procedures would undoubtedly be adopted again. The point being made here is simply that it isn't necessary to dent airframes or FOD engines to incur significant (and generally unavoidable) costs. The bird involved in this bird strike was small, too small a target for the B-707 crew to acquire and an aircraft too large to take any kind of rapid avoiding action so close to the ground, even had the crew been able to spot the bird in time.

We may never eliminate the bird/aircraft problem whilst both insist on sharing the same airspace. However, it is important that we take whatever steps possible at all management levels to help minimise the problem. One example of bird strike minimisation, bird control at airports, is discussed in this edition of *Focus*. God forbid that we should ever experience a tragedy like the one at Elmendorf on 22 September 1995. →

BIRD STRIKE SOLUTIONS SPURRED BY IMAGINATION

OF THE NEW YORK AIRPORTS

Condensed from an article by Mr Maurice Martin, US-based freelance writer.

Although only three fatal air transport accidents have been linked to bird strikes, many less serious accidents continue to be caused by aircraft-bird encounters, and the possibility of a bird strike-caused disaster can never be ruled out. Techniques to counter the threat include strike-resistant engines, lights, noise, airport ecology management and, at one airport, pigs.

Researchers and airport operators are developing new and innovative methods to reduce bird strikes in the airport environment. While some solutions involve the testing and implementation of sophisticated, high-tech gear, decidedly low-tech and natural methods are also showing promise.

Bird strikes are potentially dangerous and occur everywhere in the world. An International Civil Aviation Organisation (ICAO) reporting system data base reveals that between 1986 and 1990, 877 strikes were reported in Africa; 4 131 in Asia and the Pacific; 204 in the Caribbean and South America; 217 in the Middle East; 9 980 in Europe; and 6 922 in the North Atlantic and North America.

During 1991 and 1992 (January to mid-November) 842 and 327 bird strikes, respectively, were reported to the Airports Group of Transport Canada. ICAO received an average 5 480 bird strike reports annually from member nations from 1984 through 1989, although only about 60 per cent of members reported. About 11 per cent of the bird strikes had an effect on flight. Of those, 45 per cent caused a precautionary landing, 35 per cent required aborting a take-off, and 11 per cent caused engine shutdown.

Bird strikes affect aircraft of all levels of technological sophistication. The first plane brought down by a bird strike was a Wright Brothers designed biplane flown by aviation pioneer Galbraith Perry Rodgers. A gull became jammed into the aircraft's controls, causing the accident. Rodgers, best known for completing the first transcontinental flight in 1911, died in the crash near Long Beach, California, U.S.

From Rodgers' biplane [see story page 27 - Ed] to the high-tech B-1B bomber represents 70 years of aviation advances. Nevertheless, during a flight near La Junta, Colorado, USA on 28 September 1987, a bird strike on a B-1B had the same fatal effect. Three of the six-man crew died after the aircraft hit a 15 lb bird, possibly an American white pelican or sandhill crane. The bird strike ruptured the plane's hydraulic control system, starting a fire and causing loss of control.

Bird vs aircraft

A large bird can penetrate a windshield or damage other aircraft surfaces that are critical to safe flight. Moreover, ingestion of birds into engines can lead to engine failures. A modern jet engine is designed to withstand some damage from bird ingestion, but flocking birds are especially threatening because ingestion of multiple birds can result in an engine failure. Depending on the weight of the bird and where it hits the aircraft - large airliner or small general aviation aircraft - damage can range from negligible to catastrophic.

Since 1960, worldwide there have been 18 bird strike accidents that resulted in a crash or fatality involving aircraft weighing 12 500 lb (5 700 kg) or more. Worldwide, ICAO reports 169 lives known to be lost to bird strikes between 1912 and 1992. The FAA attributes 104 civil aviation fatalities in the United States between 1912 and 1986 to bird strikes.

In 1988, in Bahar Dar, Ethiopia, a Boeing 737 flew into a flock of about 1 000 speckled pigeons, and 10 to 15 birds were ingested into each of the two JT8D engines. The engines failed before the crew could complete an emergency landing, and the ensuing crash killed 35 people.

In October 1960, a Lockheed Electra ingested a flock of starlings into three engines and crashed into the harbour at Boston, Massachusetts. Sixty-two of its passengers and crew died. Also during the 1960s, a British Vickers Viscount transport collided with an 8 lb swan, which destroyed the aircraft's vertical tail. The subsequent crash led to improved structural designs that would withstand bird strikes.

For pilots, the most important evasive action that they can take is on the ground. They should delay take-offs until flocking birds are cleared from the runway. In the United States, pilots and operators are encouraged to report all bird strikes to the FAA, because problems and solutions cannot be addressed without accurate data. Bird strike data may not be accurate because of under-reporting in the United States and other countries.

One Boeing researcher reported that of all turbine-powered commercial aircraft fatal hull-loss accidents, three (0.9 per cent) have been caused by bird strikes. The percentage appears small, but it is a significantly larger percentage of engine-related accidents. A study of bird strikes reported by European airlines found that engine strikes comprised 16.8 per cent of all strikes, and 1.3 per cent of the total affected more than one engine (Fig-

ure 1). Data for 1981 to 1985 included 59 cases where birds struck all of an aircraft's engines.

Often dangerous for humans and always deadly for birds, strikes can be costly even when no human casualties result. Bird strikes in Canada between 1985 and 1987 resulted in damages totalling Canadian \$6.6 million. But reported losses are often underestimates, because the reported losses do not include lost flying hours, fuel or disruption of passenger and freight transportation.

Many airports around the world have the same problem as Anchorage's Lake Hood Seaplane Base—in one way or another, they provide an environment attractive to birds, increasing the likelihood that aircraft taking off and landing there will experience a bird strike. Some biologists and air safety experts believe that the most important factor in reducing the overall number of bird strikes is the understanding and manipulation of environmental factors in and around airports. In this sense, bird strikes challenge humans to be better managers of land, water and animal populations.

Where birds gather

Most aircraft bird strikes occur at or near an airport during take-off or landing, and this is where bird control must be focused. Although the hard, flat tarmac of a busy runway may seem noisy and unappealing to humans, it can be a very attractive environment for birds.

Tarmacs and runways are often feeding grounds where birds find worms during a rain storm. Worms can suffocate in earth that is saturated with water. When it rains, they crawl up onto pavement and can be found on streets, sidewalks and runways. Because airports tend to be very flat and drain slowly, worms stay out of the ground long enough to attract birds. Moreover, crows have been known to kill rats by dropping them on tarmacs.

Birds also find food in the grass between runways, the ornamental shrubs found at some airports and crops

planted in surrounding fields. Some birds, such as gulls, like open areas, and many will quickly adapt to the incessant din of jets at a busy airport. Fences surrounding airports can create, in effect, small wildlife preserves that afford birds some protection from predators.

John F. Kennedy International Airport (JFK), New York, almost is a legal wildlife preserve. It is located adjacent to the Jamaica Bay Wildlife Refuge, whose marshes contain a colony of laughing gulls (*Larus atricilla*). Between 1988 and 1990, this species played a role in 52 per cent of the bird strikes at JFK (involving an average of 302 aircraft a year).

Moreover, airport designers sometimes accidentally build in extra bird strike hazards. This happened at the Lake Hood Seaplane Base. To separate the take-off canal from the slow taxi canal, a strip of land 2 000 ft by 125 ft was put in between the two waterways. With no predators, it quickly became a nesting spot of gulls, geese and ducks. 'Gull Island' as it was dubbed, had become an inadvertent bird strike hazard.

Civil planners can create a bird strike problem too, such as when a town decides to put a land fill at the end of a runway. This may seem like a good idea because the land around airports is so noisy. Structures built near airport approach paths can also make an area more attractive to birds.

Human development of real estate favours some species over others. Nevertheless, once cleared for human use, the area is more likely to attract gulls. Being slow, clumsy fliers, gulls appear in more than 50 per cent of all strikes.

Statistics from the ICAO data base indicate that in strikes between 1984 and 1989, where the species of bird was determined, flocking gulls and terns (in a combined category) were involved in the largest number of cases, followed by 'perching birds' hawks/eagles, lapwings/plovers, pigeons/doves and 'other'.

The fact that we have a growing human population means there's a growing need for things like airports and

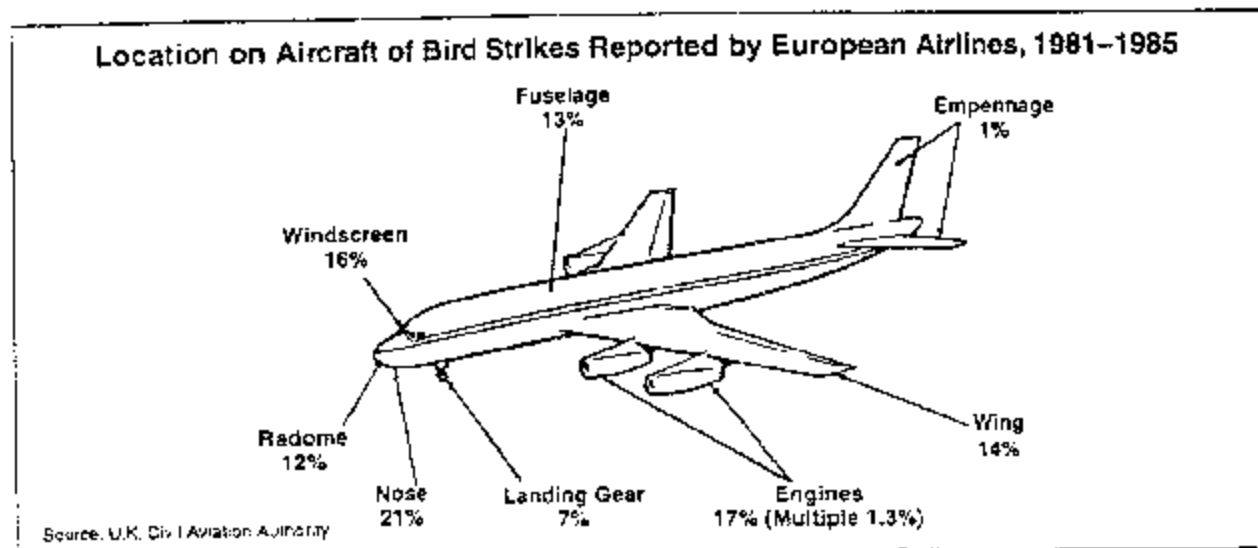


Figure 1.

land fills. As we get closer together, there are a lot more friction points between humans and animals.

Designers seek ways to minimise bird strike damage

Aircraft and engine designers have invested millions in research and development to design aircraft to better withstand bird strikes. To determine how aircraft components withstand the impact of a bird's body at high speeds, for example, researchers have mounted aircraft components onto rocket sleds, accelerated them to air speed and directed them to run into dead chickens suspended from scaffolds. They have also used impact-simulator guns to hurl dead birds into propellers, windshields and jet engines.

The engines for the Boeing 777, the world's largest twin-jet aircraft, introduced into airline service during 1995, are required to be able to ingest four 2.5 lb (1.14 kg) birds while in operation and still produce at least 75 per cent of their full thrust rating.

The products of this type of research have made large passenger aircraft much safer from the effects of bird strikes, but older aircraft and engines, which did not have the benefit of modern technology in their designs, will remain in service for many years.

But bird-proofing aircraft does not address the harm done to the birds, another reason why environmentalists and governments are increasingly looking for humane as well as practical responses to bird strike hazards at airports.

A study sponsored by Transport Canada evaluated the use of strobe lights on aircraft to increase birds' awareness of aircraft, giving them more time to take evasive action. In Phase I of a planned two-phase experiment, laughing gulls were subjected to strobe lights of varying wavelengths and frequencies to determine their responses. Measurements of the gulls' heart rates indicated that they did respond physiologically to the strobes. But Phase II of the study, which was to have tested whether aircraft-mounted strobe lights could help the birds' avoidance manoeuvres, was cancelled because in-flight testing was deemed neither technically nor financially feasible.

Airports remain focus of actions

One way to reduce bird strikes is to make airports unappealing environments for birds. Among technologies that are being tried or considered are application of methyl anthranilate to pools of water on runways, ultrasonics, falconry, sanitary land fill management and air-field habitat management.

An FAA-sponsored wildlife management program is in place at Atlantic City International Airport, New Jersey. Its elements include: wildlife harassment training; an airport bird study; detailed biological studies; bird strike data compilation; bird harassment program; minimisation of water attractions for birds; long-grass management; insect control; opposition to solid-waste

facilities near the airport; and, long-term research on habitat management.

There are also modern equivalents of the traditional farmer's standby, the scarecrow. In the 1960s and 1970s, engineers experimented with laser beams, hoping that an aircraft-mounted laser could burn or scatter birds in the path of the aircraft. This did not prove effective and would have posed a hazard to humans wandering into the laser beam's path.

Two different bird-scaring systems tried on Gull Island to clear the seaplane base of birds are: shell crackers, a kind of shotgun shell with an explosive charge in the projectile, which were fired above the birds to scare without injury; and screamers, a kind of noise-maker shot from a specially designed pistol. Sometimes, simply a human presence will get birds to leave. Also, the birds ignored a scarecrow fashioned from a hard hat and an orange airport jump suit.

On the 15 000 acre land-based portion of the Anchorage International Airport, another bird-scaring device nestled in the grass next to a runway is used: a propane cannon. This squat device has a bladder that fills with propane, which is set off at intervals in mini-explosions, producing a bird-scaring boom. Propane cannons are somewhat effective, he said, although they must be moved regularly so that the birds do not get used to them.

Observation has found that birds will acclimatise to most forms of harassment. If the environment around an airport remains attractive, birds will return. Even if one batch of birds is killed, others will just take their places.

Reducing the attraction before harassment

Once you know what is attracting the birds, the solution may seem obvious. If it is water, better drainage might help. If tall grass lures the birds in, mow more often. Sometimes playing recordings of bird distress calls may get the birds to leave.

But it is not always so straightforward. Environmental factors that drive out birds in one area can have the opposite effect in another. Air safety experts in England have found that keeping airport grass long keeps birds away. That is because lapwings are the biggest problem there. Solutions must consider the many different geographical and ecological regions and their corresponding animal populations.

Shooting birds may be the answer although that option is always a last resort. But in extreme situations, shooting may have to be undertaken. At JFK, despite an active bird management program including habitat alteration, insect and garbage control and a full-time patrol that attempted to frighten birds off, problems persisted. Although the actions taken did discourage gulls from lingering at the airport, they were ineffectual in stopping them from flying over JFK while migrating or heading from their sanctuary on nearby US National Park Service land to their feeding grounds.

In the summers of 1991 through 1993, US Department of Agriculture wildlife biologists, working under special federal and state permits, used shotguns to kill some 35 000 gulls at the airport. The program was pronounced a success, with gull strikes reduced by about 70 per cent in 1991 and 89 per cent in 1992 and 1993 over 1988-1990 levels. (Populations of laughing gulls at the adjacent colony in Jamaica Bay were not endangered.)

Timing is important

Whatever their nature, programs are not always carried out in time to prevent an accident. The DeKalb accident is a tragic illustration. The dump at the end of the runway that attracted the cowbirds had already been cited by the FAA as a hazard and was scheduled to be closed in six months. The US National Transportation Safety Board (NTSB) investigated the crash and in its report chided the FAA for failing to do more to close the dump. Nevertheless, the FAA cannot direct what a community does. It can only advise what is good for air safety.

That suggests one of the institutional obstacles to preventing bird strikes. If prevention means changing land usage, who has the authority to demand changes? In the United States, because it is an air safety issue, the FAA is involved. But it is also an animal issue, and so the US Department of Agriculture, operating through the Fish and Wildlife Service, is also involved. And clearing out birds may mean altering the local environment, so the Environmental Protection Agency will introduce its own concerns. Add civic and state governments, land owners, airlines and branches of the military that build and maintain airports, and this issue can quickly become mired in bureaucracy.

With so many viewpoints represented, it is difficult to please everyone. But recognition of the problem at Anchorage International Airport has prompted the formation of a Wildlife Advisory Committee consisting of representatives from the airport staff, the Audubon Society and local waterfowl associations. This kind of cooperation among people approaching the problem from many directions can be an important step toward addressing bird strikes.

An international organisation called the Bird Strike Committee Europe brings together airport personnel, biologists, engineers, meteorologists, ornithologists, pilots and safety staff from many nations. Among their projects are exchanging information on airport safety and identifying bird remains to find out which birds are most likely to become involved in strikes. A Bird Strike Committee USA (BSCUSA) and a Bird Strike Committee Canada also have been formed to target their respective geographic regions.

Canadian efforts since 1980 have resulted in a dramatic reduction of bird strikes, which have been credited to airport managers and bird patrols. There has been significant improvement since 1986 in India, where field scientists have reduced the presence of large birds, in-

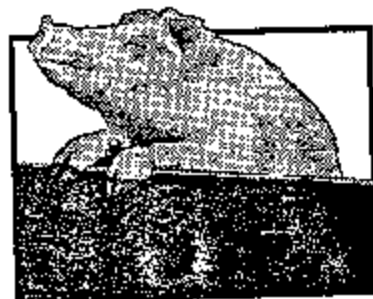
cluding vultures, near airports. The successful efforts in Canada and India demonstrate that bird hazards can be reduced when the efforts are made to reduce them.

Other efforts to address bird-strike hazards include the USAF's BASH Team. BASH analyses data from the Air Force's strikes, which numbered 2 227 in 1992 and resulted in damage that exceeded US\$23 million. BASH shares its findings with other organisations at meetings of Bird Strike Committee USA.

The FAA has created a computer data base on bird strikes in the United States and is also, in cooperation with the US Department of Agriculture, conducting research in habitat management in and around airports, birds' use of waste disposal facilities near airports, and the development and evaluation of wildlife repellent techniques.

One novel approach to bird control

One of the most creative approaches has helped reduce bird strikes at the



Lake Hood Seaplane Base. Faced with the problem of how to get rid of the birds on Gull Island, Wayne Gibson and his coworkers have turned to a low-tech solution: three hogs named Moe, Larry and Curly.

In 1993 and 1994, the airport staff turned the hogs loose on Gull Island throughout the birds' breeding season, May to August. The hogs roamed free on the island, shuffling around in the grass and eating the eggs laid by the birds. Because it is artificial, Gull Island had no predators before the hogs arrived.

Gibson has had to install a feeder to supplement the pigs' egg diet and a mud wallow to make them comfortable on warm days. He says that he will have to bring the pigs back every summer for at least five years to convince the birds to stay away. But the pig system is non-polluting, non-lethal and humane. And it seems to be effective. Though statistics have not been compiled yet, the number of bird strikes seems to be down.

One operator, whose flying service used to have two or three bird strikes per year, said that the program has been a success so far, with no bird strikes in 1994. He added that 'those pigs are the first thing that's ever worked!'

About the author

Maurice Martin is a freelance writer based in Arlington, Virginia, USA. His articles on wildlife and environmental issues have appeared in the following magazines: Zoo-Goc, Destinations, and Glass.

THE FIRST BIRDS' TRIKE FATALITY

UNFORTUNATELY, birdstrikes have occasionally been the direct cause of fatal aviation accidents and, unless we permanently ground either bird or machine, this pattern will almost certainly continue.

The first birdstrike fatality recorded was that involving Galbraith Perry Rodgers, great great grandson of Commodore Perry. He was a socially prominent member of the New York Yacht Club and a former Columbia University football player. At 193 cm (6ft 4ins) he was also one of the tallest aviators. In 1911 he captured the imagination of the entire nation when he became the first ever to fly coast-to-coast USA. Leaving Sheepshead Bay, New York on 17 September at an average speed of 50 mph, his goal was to complete the trip in 30 days and win a \$50 000 prize offered by William Hearst. He became lost the first day, however, when he followed the wrong railroad tracks – the navigation system of the day. The following day he crashed into a tree ensuring that he wouldn't get to California in a month. After extensive repairs he continued the trip and subsequently landed in a swamp he mistook for a field. Later, he shredded a propeller on a barbed-wire fence. Still later he crashed trying to fly under some wires. When he landed in Pasadena, California on 5 November to the cheers of 20 000 admirers, all that remained of his original aircraft was the vertical rudder and the drip tray!

On 3 April 1912, a seagull became entangled in his external controls whilst he was executing an aerobatic manoeuvre 100 ft over Long Beach. Seven thousand people watched in horror as he plunged into the surf and perished. It's ironic that this well-bred, well-educated national hero, who had survived so many crashes, should meet his end due to a birdstrike.

And today?

We cannot afford to relax because bird strikes at a particular location have been infrequent or minor, the stakes are too high. Prevention of bird strikes, like cricket or baseball, is a game of centimetres. A 10

centimetre difference in impact point may be the difference between a dead bird and a dead pilot.

Many engines have been fiddled too. Any time a bird enters an engine the potential exists for a catastrophe. Even if the aircraft is successfully recovered after such a bird strike, the resultant repair bill for the engine can be huge.

Bird strikes can be minimised by observing the following basic rules:

- study bird habits for your area and avoid conflicting altitudes and areas;
- avoid low-level flying where practicable;
- avoid flying under bird formations to escape the hazard – the diving tendency birds have demonstrated when approached by aircraft may exacerbate the situation;
- eliminate touch-and-go landings during periods of heavy concentrations of birds in the vicinity of airfields – many bird strikes occur in the landing pattern;
- report concentrations of birds to ATC;
- the use of taxi and strobe lights may help birds that migrate at night to see and avoid you;
- air stations can exercise bird control measures – eliminate refuse and feed-producing vegetation, and remove trees and shrubs that serve as bird shelters.

With all the possible emergencies/threats that pilots face on a daily basis, the bird strike has got to be one of the most sudden happenings to occur. With thoughtful flight planning and briefing, this risk can be minimised. So keep your head on a swivel and if you can't avoid a bird ... why, duck of course.

Finally, for the recreational pilots

Slower flying aircraft are not exempt from bird strikes, whether accidental or otherwise. A few years ago an RAN Gliding Association glider was attacked by a large eagle on three successive flights during the National Gliding Championships at Benalla, Victoria. On each occasion the attack occurred at a fairly localised area near the airfield, at 5 000 AGL and well clear of high ground. The attacks, lasting between 30-60 seconds, understandably terrified the two occupants in the relatively frail machine, as well as causing the starboard wing tip to be holed on each occasion, necessitating overnight repairs. It was the only aircraft attacked and attributed to the unusual glider colour scheme of red wings and silver fuselage!



HARRIER DOWNIED BY BIRD STRIKE



(Extracted from April 1994 issue of *RAF Air Clues*)

ON 28 June 93, Harrier GR7 ZD430 was returning to Germany as No 2 in a three-aircraft formation. The formation were routing to the east of RAF Coningsby when No 2 felt a 'small thump' on the starboard side of his aircraft. Suspecting a bird strike, the pilot checked his engine indications and visually checked the aircraft surfaces but all appeared normal. No 3 then noticed vapour emitting from the starboard side of No 2 and asked its pilot whether he was dumping fuel. No 2 commenced a climb and replied that he suspected that he had suffered a bird strike. He then re-checked his aircraft for damage and noted fluid leaking from the starboard wing and covering the whole top surface with vapour. The right group fuel gauges were also decreasing faster than the normal fuel dump rate.

As No 3 closed in to provide assistance, he noticed a flash fire on the starboard side of No 2. Almost concurrently the engine bay FIRE warning illuminated. The No 2 pilot brought the throttle to idle, selected the engine's manual fuel system and checked visually for signs of fire. None were observed. At this stage, communication was hindered by No 2 missing a frequency change and by a Practice PAN blocking Guard. No 2 once again checked for signs of fire and saw a glow reflected in his starboard CBLS. He then noticed that a major fire was quickly spreading to the inboard section of the wing. Approximately 40 seconds after the fire warning had first illuminated, No 2 made another R/T call and ejected. No 3 attempted to relay information to the Distress and Diversion Cell, but experienced problems because of the Personal Locator Beacon tones and Practice PAN calls.

The investigation

During their investigations, the Board found clear evidence to indicate that the aircraft had suffered a massive fuel leak, followed by a fire

in Zone 2 of the engine bay and in the area of the right trailing edge main flap. After a detailed examination of the Harrier's fuel system, the Board deduced that the leak had emanated from the inboard section of the right wing tank.

In considering the cause of the leak, the Board discounted mechanical or structural failure. Initially, thoughts of damage to the leading edge of the wing were discounted because the pilot did not notice any damage to the area. However, an investigation into a Harrier GR5 bird strike in 1991 had shown that, despite minimal

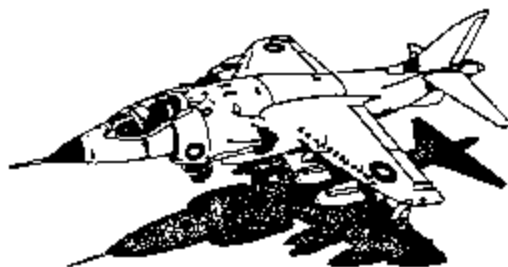
Time	Station	Narrative
13:07:11	No 3	2, are you dumping?
13:07:12	Guard	Charlie Oscar Tango
13:07:13	No 2	Negative...pulling up now, I've got a birdstrike
13:07:17	No 3	OK, I'm coming aboard
13:07:20	No 3	2, are you reading
13:07:24	No 2	Affirm
13:07:25	No 3	2 has got a problem...2, you have a small fire, suggest you come up Stud 19
13:07:31	Guard	and Charlie Oscar Tango 34 Practice PAN
13:07:36	No 2	OK, I think I've got a fire warning here
13:07:37	Guard	Charlie Oscar Tango 34 London Centre, your position is...
13:07:39	No 3	2, you have a...are you up on 19
13:07:42	Guard	Charlie 34, 2 POB...hydraulics ...simulated Mayday
13:07:45	No 2	3, come alongside please
13:07:48	No 3	2, you have a fire on your starboard side
13:07:51	Guard	For Linton steer 270, range 15 nm
13:07:57	No 3	2, are you reading
13:08:00	Guard	...270 Charlie 34
13:08:02	No 3	2, are you reading
13:08:04	Guard	Charlie 34 squawk 7301
13:08:05	No 2	Affirm...On fire, ejecting
13:08:07	No 3	2, you are on...a major fire
13:08:09	Guard	Runway 22 right hand, 6,000 ft available, fully serviceable for approach
13:08:16	No 3	Mayday Mayday, Mayday

leading edge damage, the front carbon composite spar had cracked. Furthermore, the spar forms the forward face of the wing's integral fuel tank. The Board assessed that an impact by a foreign object close to a wing rib could cause sufficient damage to produce a fuel leak. In conclusion, the Board established that the cause of the accident was a fire brought about by a massive fuel leak, which ignited on contact with the hot nozzles and on contact with the engine outer casing in Zone 2. The cause of the fuel leak was probably an impact with a foreign object, most likely a bird, on the starboard wing leading edge.

In the light of the loss of ZD430 and the 1991 incident, the Board concluded that the design of the wing leading edge and of Zone 2 contributed to the accident. A review of the Harrier's bird strike resistance was recommended and is currently being undertaken.

'Wing Commander Spry' says

Much has been said in the past concerning *Guard* and its use or abuse. The extract from the transcript on page 20 shows the problems that this formation experienced (Note that the call signs have been changed to protect the guilty!)



This is not an attempt to pillory those who regularly need to use *Guard* for Practice PANs. In this case the aircraft on *Guard* would not have been aware of the developing situation at low-level. However, the introduction of the Practice Emergency Training Frequency in 1995 should keep *Guard* clear for its primary use. The lesson here is that James' *All The World* emergency services are available to you on *Guard* but only if you chop across to 243.0 Mhz and use them.

As you can see from the transcript, very little time was available to No 2. The transition from a low workload flight to the ejection took a little over one minute. The speed at which the fire engulfed the aircraft is also worrying and has led to the removal from Harrier FCCs of the requirement to wait 30 seconds if signs of fire are confirmed. Fortunately, this pilot got out when he should — *he ejected in time.*

This incident also serves as a graphic reminder of the need to divert after a bird strike, even when no damage is apparent. Over the years, there have been numerous instances of bird strike related engine damage which was not detected in the air. Although it appears that the Harrier has a particular problem, the message applies to all low-level operators. →

AND ONE THAT RECOVERED TO BASE SAFELY

THE SOLO STUDENT was on a Hawk low-level training sortie and cruising at 500 ft AGL when he saw a large seagull only a split second before impact. The canopy was shattered leaving miniature detonating cord (MDC) from the remaining canopy dangling around the pilot's neck and shoulders. Perspex entered the cockpit, breaking the gunsight and striking the pilot's right leg. Various panel warnings illuminated and the TGT was noted above 685°C.

The pilot climbed the aircraft and turned towards the nearest airfield while, at the same time, throttling back to idle. The TGT dropped and then stabilised around 350-400°C, so engine RPM was increased to 87 per cent. The speed at this point was 270 kts. Although the pilot suspected engine damage he decided not to jettison his stores as he was close to built-up areas.

The engine RPM and TGT remained stable but neither engine noise nor the R/T could be heard due to the very loud wind noise.

A route was then flown just skirting the coast, remaining VMC and avoiding built-up areas. The aircraft was then positioned over the airfield where low speed handling characteristics were checked

without any problems being detected. The aircraft was subsequently landed from a fixed-power circuit and the engine shut down after the aircraft had been taxied clear of the runway.

Counting the cost

A later engineering investigation revealed the full extent of the damage caused by the impact of this large bird with the aircraft flying at 420 kts. The damage, assessed as Cat 2, included:

- a FOD-damaged engine requiring replacement;
- a shattered canopy;
- damage to the port side of the front seat head box requiring replacement;
- a damaged front cockpit gunsight;
- torn internal skin in the port intake;
- dents to both tailplane leading edges;
- a dented fin leading edge; and
- tears to the port wing upper skin and honeycomb. →

THE RAF: How they're dealing with the bird strike problem

THE last RAF Car 5 accident attributed to a bird strike happened over three years ago? Yes, it's a fact, but it's also a fact that, despite the draw-down, RAF bird strikes over the past five years still number over 600 per annum (a rate of 13 per 10 000 flying hours) which is the traditional norm. The vast majority cause little or no damage but it is estimated that bird strikes cost the RAF in excess of 15 million pounds per year and this figure does not include the cost of any replacement aircraft should one be required. The statistics show that on-airfield strikes account for 21 per cent of the total whilst off-airfield strikes account for 58 per cent – the remaining 21 per cent are discovered after flight, possibly most of these happen off-airfield too.

The on-airfield figures have gone down a few percentage points over the last few years and this is testimony to the introduction of full-time, professional BCUs being established at most of the major RAF airfields.

In terms of aircraft types, the fast-jet fraternity have the most bird strikes (47 per cent) whilst training aircraft, including the Hawk, have 30 per cent. Multi-engined aircraft at 15 per cent and helicopters at eight per cent account for the rest.

Ninety five per cent of all bird strikes in the UK occur to aircraft flying below 2 000 ft. Therefore, statistically speaking, your average fast-jet jock flying away from the airfield in the UK Low Flying System (UKLFS) is the most at risk from an unwanted encounter of the feathery kind. So, what countermeasures to bird strikes are available to help now and what is planned for the future?

What you can do

First of all it may be timely to remind you of what you can do to help and protect yourselves: visors should be kept down and all operators should fly no lower or faster than is operationally necessary when low flying. A reduction of just 60 kts from say 480 kts to 420 kts can reduce the impact force of a bird by as much as 25 per cent. In addition, you should plan to cross coastlines at right angles at a minimum altitude of 500 ft (preferably higher). Certainly higher if SOPs dictate and be aware of the bird concentration areas. We are now well into the autumn/winter migration of birds across the UK and the Continent; therefore, the birds you might encounter now are generally bigger than the smaller birds which abound in the summer, and they consequently have the potential to inflict more damage to you and your aircraft. You can also help your fellow man by reporting any bird concentrations you do see in the UKLFS, or for air traffickers on your radars.

OK, but what, I hear you ask, is the Inspectorate of Flying Safety (IFS) doing about the bird strike problem? Well as our remit is mainly for the off-airfield or en route problem we have been progressing two projects during the last few years which concentrate on this aspect of the problem. The first of these is the radar detection project definition study which arose after the Watchman trials in the early nineties. The final report from the contractor is yet to be received but all the indications are that to provide adequate low-level radar cover, capable of detecting birds across the country, is all but impossible and the projected costs just to introduce a skeleton system are not realistic.

Locally, however, radar may be part of the solution around airfields. Kinloss is a case in point and radar trials there to detect the movement of Canada Geese give some encouragement to the development of a system which could be a useful tool in combating that particular menace. On a national scale though, we feel that the use of radar to detect bird activity and provide real-time warnings is unlikely in the foreseeable future. On the other hand, the development of our Bird Avoidance Model - Geographic Information System (BAM-GIS) shows more promise. The BAM-GIS (BAM is the American vernacular that appears to be universally accepted) is essentially a database of known and predicted intense bird activity collated by scientists of the MAFF Central Science Laboratory (CSL). Bird strike Avoidance Team (BAT). The data they have amassed includes information on all known bird breeding, feeding, roosting and nesting sites in the UK lower airspace where bird intensity is known to be significantly above that of the ambient background level. Seasonal variables, time of day etc have also been included in the data which is incorporated with an electronic ground map. You can then enter details of your flight on the map and interrogate those areas highlighted as potential bird hazards on or close to your intended route. Information is presented about the hazard eg, the type (land-fill site etc) and an assessment of the species and number of birds which could be encountered. Furthermore, a subjective evaluation of the risk (high, medium or low) at each site at a variety of altitudes (100 ft, 250 ft, 500 ft and 1000 ft) is provided. The decision to avoid hazards either vertically and/or laterally is then up to you.

During its early life it was envisaged that the BAM-GIS would be displayed via ALFENS but such is the nature of the software, not to mention the problems with ALFENS itself, that the GIS has been developed to run on a free standing Pentium PC. The next phase of the project is to subject the BAM-GIS to aircrew scrutiny and by the time you read this it should be on operational trial on a fast-jet squadron. Further progress with the

system will depend on the customer's reaction, but whatever the results of the trial, the bird activity data gathered during the development is vastly superior to anything we've had hitherto. We should be able to find a use for this information – even entries in the UKLFHB would be better than doing nothing with it. The USAF Bird Avoidance Strike Hazard (BASH) Team are certainly very interested in what we've been doing as they are looking to produce their own GIS for USAF aircrew.

Currently, in the USA they do provide a BAM for some of their low level routes but they don't have a map to marry their data with; we're ahead of them in this regard. They also produce a local BAM for each of their major airfields from data collected by their BCUs. Crews refer to the BAM much as they do to the latest

NOTAMs and it is an integral part of the pre-flight briefing. Some of our airfields already have such a system in place but the concept is not commonplace across the Service.

It's here to stay

The bird strike problem will never go away entirely but there are measures that we can take to reduce the risks to ourselves and our aircraft. Please continue to report all bird strikes, however insignificant some of them may appear to be. →

Courtesy RAF Air Chives (Issue October 1996)

BIRDS ARE EVERYWHERE!

THE DAMAGE depicted in this article is to the cockpit area of a RAF Tornado GR1 cockpit canopy and surrounds resulting from a bird strike, and to the 'spray' of the bird remains on the pilot's personal flying equipment.

We have it on good authority that the GR1 cockpit is a pretty reassuring place, with lots of thick glass and chunky ironwork to repel flimsy sparrows, should they choose a 180 by 0 intercept. The RAAF F-111, for example, is also a tough aircraft suited to the low-level environment. This could lead the unwary to be tempted to fly with their visor up. Think again! What would the result have been if all that gunk from the bird had hit the RAF pilot a little bit higher, and his visor had been up?

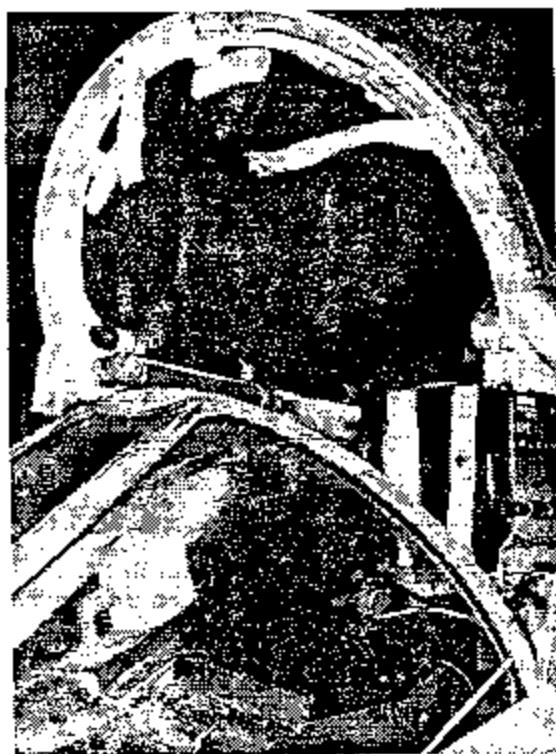
The GR1 was flying at 420 kts and 400 ft when the pilot sighted a large flock of birds but too late to take avoiding action. The aircraft hit a straggler which impacted on the left of the windscreen, just below the canopy arch. It didn't break any glass, but somehow slid up the windscreen and entered the cockpit via the small gap between the windscreen arch and the canopy arch, taking out the canopy seal and some of the associated ironmongery. As it came through, it got turned into pate which then hit the pilot full on the chest, with the rest of the cockpit getting a liberal splattering. The pilot had his visor down, which, by getting in the way, stopped any of the chewed flesh entering his eyes. The impact was strong enough to severely wind him and, as he was later to find out, to cause some bruising to the torso and left thigh.

There was a fearful noise and a rush of air, and the pilot struggled with the controls. Fortunately he was able to subsequently effect a safe landing.

The moral of the story is clear: Had the trajectory of the remains been slightly different as they entered the cockpit, and had the pilot's visor been up, it is fairly sure that the aircraft could not have been landed safely.

The crew of RAAF F-111 A8-133 were not as fortunate as the GR1 crew. On 29 September 1977 they suffered a catastrophic windscreen multiple bird strike during a low-level bombing pass at Evans Head Air Weapons Range in NSW. Both crew were severely incapacitated by the bird strike, reported to be three pelicans and perished when their escape capsule was deployed outside the survival envelope. (See article page 1.)

Aircraft windscreens will not keep *all* birds out, so make sure you keep your visor down! →



Bird strike damage incurred by RAF Tornado GR1.

ENGINE INGESTION HAZARDS: Birds and FOD

Condensed from an article by Mr Thomas Alge, Staff Engineer,
Bird Strike Ingestion Control, GE Aircraft Engines.



MORE aggressive corrective measures are needed in international air transport to reduce the chances of serious accidents from ingestion encounters. This paper is intended to offer insight and understanding of the causes and effects of ingestion threats and sound a call to action for preventive and avoidance actions to counter the threat of a multiple-engine power-loss occurrence.

Bird strikes to engines have caused major accidents with fatalities on two large commercial transports since 1960 and bird strikes to engines have resulted in at least 12 other accidents.

The first major accident with fatalities caused by a bird ingestion was in October 1960 when a Lockheed Electra ingested a large number of starlings and lost power on three of its four engines. The aircraft crashed into Boston Harbour. This event led to the introduction of certification requirements for engines to demonstrate flocking-bird ingestion capabilities.

The second major accident with fatalities was in September 1988 when a Boeing 737-200 ingested a large number of speckled pigeons in both engines during a takeoff at Bahar Dar, Ethiopia. During the air turn-back, both engines lost power. While attempting an off-airport landing, the aircraft struck a river bank and burned.

Even more recently, in September 1989, a Boeing 747 ingested multiple pigeons in both of its left wing engines during take-off from Los Angeles. Both engines lost power, and a disaster was narrowly averted as the crew brought the aircraft safely back to Los Angeles. Birds also represent a hazard to the aircraft structure. By way of historical note, a British Vickers Viscount transport crashed in the 1960s from impact by an 8 lb whistling swan that destroyed the aircraft's tail. This event led to the establishment of a design requirement to assure capability of continued safe flight and landing of an aircraft after impact of an 8 lb bird on the empennage.

Clearly, the collision between birds and aircraft is a serious safety concern. Bird ingestion studies conducted through the years by the US Federal Aviation Administration (FAA) are well documented in terms of the exposure to various bird types and engine damage consequences. However, no recognised independent organisation has monitored worldwide bird strikes with the purpose of identifying and correcting airports with bird hazards. At GE Aircraft Engines, we receive bird strike information on our engines. This limited amount of data from one manufacturer shows that there are several areas with potential bird ingestion threats.

Engine familiarisation

As engines have become larger, the frequency of bird ingestions has also increased. This is primarily a result of the larger forward capture areas. These types of engines power today's large commercial transports because of their high thrust capabilities and low specific fuel consumption. Such engines produce more than 60 000 lb of thrust and typically have inlet capture areas of 5 000 square inches or more.

Ingestion threats

Most engines in service today were designed and certified to meet the ingestion of flocking birds (up to eight 1.5 lb birds per engine) at the most critical ingestion conditions for take-off. This is intended to represent typical flocking-bird encounters at airports. It must be recognised, however, that there are flocking-bird conditions in nature beyond the certified capability of the existing engine fleets.

A threat from flocking birds is the potential for a multiple-engine power loss from the ingestion of an abnormally large number of birds in each engine. The ingestion of a single large bird during the critical period of take-off is also a potentially hazardous condition. Such occurrences, although predominantly single engine events, have resulted in runway departure accidents. However, multiple-engine power loss caused by ingestion of flocking birds is the occurrence that is the greater threat.

Of course, any exposure to an ingestion condition that is more severe than that for which an engine was designed and certified presents a potential ingestion hazard.

Ingestion experience

On the CF6 and CFM56 commercial high-bypass engines, bird strikes represent 90 per cent of all known ingestion events and are a major ingestion concern. Atmospheric icing and ice slab ingestions account for 1.4 percent of all known ingestion events. Other known ingestion occurrences involve foreign objects (8.7 percent), including runway materials, ice on runways, land animals and litter. There have also been a number of foreign object ingestion events where the source was not determined.

Most of these ice and foreign object damage (FOD) ingestions have been single-engine events. The main multiple-engine threat comes from flocking birds.

Bird strike statistics

The reported single and multiple engine bird strikes on CF6 and CFM56 engines are displayed in Figure 1. For the single-engine events, 3.3 per cent had more than one bird ingested. Multiple-engine ingestions represented approximately four per cent of the total bird ingestion events. More than seven per cent of the bird strike runback events had multiple-bird involvement.

A breakdown by aircraft flight regime of the bird ingestion history of Figure 1 is shown in Figure 2. More than 98 per cent of all commercial CF6 and CFM56 engine bird strikes occurred at or near airports during the take-off, climb, approach and landing flight phases. On or near airports is where the bird control efforts must be focused.

The frequency of ingesting migratory bird flocks in flight has been low; however, when these ingestions occur the results can be severe. Efforts to identify and avoid this very real threat should continue.

FAA bird study

The FAA bird study on Boeing 737 aircraft engines was based on three years of data collected by General Electric and Pratt & Whitney. This worldwide study included 1 468 engines with bird strikes that, because of multiple-engine events, involved 1 410 ingestion events on CFM56-3 and JT8D engines.

The exposure frequency of Boeing 737 aircraft engines to multiple birds was 14 per cent. Four per cent of the ingestion events were multiple-engine ingestion events. Approximately 20 per cent of the more serious events had an operational effect, including the one accident with fatalities at Barhar Dar.

The Barhar Dar accident was caused by the ingestion of an abnormally large number of 10-12 ounce speckled pigeons in both engines during take-off. These pigeons had a history of flocking at Barhar Dar in September, reportedly attracted by seeds near the airport runway. There was no airport bird control program in effect at that time.

The results from this and other industry studies show that in the 2-2.5 lb range there is an important flocking bird threat, primarily from herring gulls. The concentrations of the 2.5 lb herring gulls at coastal airports worldwide has been a major concern.

Certification requirements

Industry and regulatory agencies are in agreement that both the multiple 1.5 lb and the multiple 2.5 lb flocking birds must be addressed in the certification requirements for medium-size birds. The existing requirements address only 1.5 lb medium-size flocking birds and the 4 lb single large bird.

New and more stringent certification requirements have been proposed that, in addition to the added 2.5 lb flocking bird requirement, would increase the size of the single large bird to 8 lb for large engines.

These new certification requirements would require an engine to produce at least 75 per cent of take-off thrust and operate for 20 minutes, instead of the current five minutes, following ingestion of a volley of medium-size birds at the most critical take-off conditions. This demonstration simulates a flocking bird encounter during take-off and a safe air return.

The demonstration of a large bird ingestion at climb conditions represents a typical in-flight encounter; the engine must be capable of being safely shut down within 15 seconds and not lead to a condition potentially hazardous to the aircraft.

Role of engine manufacturers

Engine manufacturers are required under regulations to design engines that will withstand defined ingestion criteria. These must be demonstrated during the engine certification process.

Through the years, engine manufacturers have collected details on the extent of damage from bird strikes and other ingestion events, using the reports from flight crews, airline operators and manufacturers' field representatives.

At GE, the descriptions and the consequences of each ingestion event are documented in a computerised ingestion data base to refine the analytical design techniques and to provide engines that will meet the certification requirements.

Lessons learned during revenue service experience have led to fan design improvements that have resulted in approximately a ten-fold reduction in frequency of ingestion-caused major fan damage events. Additional improvements will appear in the next generation of engines. The GE90 engine and new CFM56 models are being developed and certified to the proposed more stringent bird ingestion requirements.

Although new engines will have increased bird strike capability, the older engines will remain in revenue service for many years. It will always be necessary for airport operators and regulatory authorities to ensure that extreme ingestion encounters are avoided. Effective bird hazard controls are needed now and must be maintained in the future.

Bird strike trends (geographic comparisons)

Experience shows that virtually all bird strikes that cause an operational effect are reported to the manufacturer. Focusing on these bird encounters, expressed as a rate, provides a consistent method of identifying bird threat locations. This also permits a method to compare the bird threat at various locations and to establish and track historical trends. This approach avoids regional variations in the reporting of bird strike events, especially by bird strikes from smaller birds that cause little or no damage.

During the period 1982-1991 studies showed that the regions with the lowest bird threat include North Amer-

ica, the Pacific Rim and Europe; the regions with the highest bird threat include Latin America, Indochina and Africa. The countries currently with the lowest bird threat include Japan, the United States, France and Germany. The countries with the highest bird threat include Turkey, Holland, Pakistan and India.

There has been a significant improvement in Canada since 1980. This is a direct result of the dedication of Transport Canada, its airport managers and bird patrol teams. The active bird control patrols using their whistles and poppers and the use of trained predator birds at some locations have been effective.

A significant improvement has also occurred in India since 1986, although the bird exposure there is still high. This improvement reflects that government's dedication and the excellent ongoing work being conducted there by field scientists to reduce the presence of pariah kites, scavenger vultures and white-back vultures near airports. This illustrates that the methodology exists and that birds can be controlled when the commitment is made.

The CF6 engine data show that both the reported bird strike rates and the operational-effect rates have decreased at most geographic locations, especially since 1986. This reflects improved awareness of the need for bird avoidance, reductions in the number of larger birds at airports and the effect of fleet introductions of newer engine models.

Although the recent trend toward fewer bird strikes that cause operational effects is encouraging, the frequency of these bird strikes is still too high. Improved bird control programs need to be implemented at selected world-wide airports.

Controlling birds at airports

The presence of a flock of birds on or near an active airport runway signals that improvements in the bird control program are required at that airport. It may also indicate that there are adverse contributing factors just beyond the premises of the airport, such as bird sanctuaries, crops, garbage land fills, abattoirs (slaughterhouses) or unsanitary local conditions. In these cases, corrective actions by other regulatory agencies, working with airport authorities and local governments, are required.

Bird attractions in close proximity to airports must be identified. Birds in their daily travels from nesting or roosting areas in their search for food must be deterred from crossing airport runways and flight paths as well as resting near or on runways.

The behaviour of birds, like humans, reflects their need and search for food, water, shelter and companion-

ship. Unfortunately, many airports with uncontrolled vegetation and insects, water drainage problems and location near oceans and lakes are attractive to birds. Airport bird control programs must include knowledge of bird types and when they frequent the area, as well as the specific needs of these birds.

Bird control programs must include passive and active measures that deter birds. Passive airport terrain features include proper surface water drainage, removal of undesirable vegetation near runways and control of insects and small mammals. Active bird control patrols must regularly check for the presence of birds near runways and must frighten them away using such means as loud bangs or trained predator birds.

Engine manufacturers generally are not involved in, nor do they have directly useful experience regarding, the control of birds and FOD at airports. The authorities at airports must assume responsibility to assure that airport bird control programs are effective, remain active and are more widely disseminated and applied.

Bird avoidance

The consequences of bird strikes need to be communicated on a regular basis to airport managers and their airport bird control patrols. Flight crews and control tower personnel must be made aware through continued training of the possible consequences of flocking-bird encounters. The message is:

Operations through flocking-bird conditions must be avoided.

The challenge is to identify bird hazards before an aircraft takes off or lands. After an accident is too late. Airport bird control techniques alone are not adequate; they must be accompanied by diligent and effective communications between flight crews and ATC.

For example, when flight crews or those personnel in the control tower become aware of the presence of large numbers of birds on or near airport runways, it is their responsibility to communicate this threat. In the interest of safety, operations on that runway should cease until the bird threat has been corrected.

Summary

Birds are one of our world's most precious resources and need to be protected. However, their presence at and around airports poses a safety threat to aircraft operations. Flocking birds must be avoided or diverted.

Bird strikes represent 90 per cent of all known ingestion events. Multiple birds are involved in more than seven per cent of the bird strikes to engines and represent the primary multiple-engine threat.



The worldwide air transport industry must address all ingestion threats. It must begin now to take those corrective measures that would be carried out in the aftermath of a major accident resulting from an ingestion caused multiple-engine power loss.

The following ongoing activities need to be addressed to reduce the bird threat to aviation:

- Regulatory agencies must issue the currently proposed bird ingestion certification requirements for new engines. Manufacturers will design their new engines to address these more stringent bird ingestion certification requirements.
- Airport managers must make sure that effective bird control programs are being implemented on a regular basis. It needs to be recognised that existing fleets of engines will remain in service for many years.

- Flight crews, recognising that bird control programs will never be 100 per cent effective, must avoid flocking encounters. Threats must be corrected before an aircraft departs or lands; afterward may be too late.
- A bird threat reduction organisation needs to be formed to lead the continuing effort to monitor bird threats around the world. The problem locations must be identified and corrected.

Monitoring and taking corrective actions against all ingestion threats constitute an ongoing but most rewarding challenge. →

Extracted from the Flight Safety Foundation 45th Annual International Air Safety Seminar Proceedings.

AN UNFRIENDLY FLYING OBJECT

PICTURE IT – Canada, May 1943. A lone RCAF Avro Anson, carrying three trainee Australian navigators and piloted by a Canadian pilot, is flying over the Gulf of St Lawrence, Nova Scotia. The purpose of the flight is a navigation exercise over the ice floes in the Gulf, but the pilot has other ideas. As soon as the scheduled work is finished, he starts 'shooting-up' the fishing boats which are dotted about the murky, cold sea. No doubt great fun for him, and undoubtedly good training for any future he might have as a ground attack pilot. However, as one of the navigators, I must say that it was a very hair-raising experience and I felt decidedly uneasy.

It must have been scary too for the fishermen – and uncomfortable, for the boats were left rocking madly in the maelstrom created by the aircraft's slipstream.

Then it happened! The pilot was making his third pass over one particular boat and I can still see it – a fisherman stood up and threw something at us. There was one heck of a bang and a neat half inch diameter hole was punched through the right hand windscreen. Sitting in the copilot's seat, I was immediately covered by fish scales. It was a fish that he had thrown at us! There were scales all over the maps and equipment, but fortunately, no guts or other fishy remains.

A very chastened pilot set course back to our base at Summerside, Prince Edward Island, and he directed me to make a log entry 'Struck by seagull'.



It was a frightening experience and it could easily have led to disaster if the fish had struck the pilot's windscreen instead. No doubt we all learned an obvious lesson that day – don't shoot up fishing boats! Later, while relating the adventure to our mates, we could see the funny side of the flight, especially the bit about the seagull. Much later, I was a navigator on Coastal Command Wellingtons, carrying out E-Boat patrols off the Dutch coast. Although our aircraft was hit many times by light ack-ack, nothing made the noise – or scared me as much – as that first encounter with an unfriendly flying object.

DFS comment

In more recent times, objects thrown at low flying aircraft have included such items as native's spears – hardly the sort of thing an aircraft crew want to have penetrating their windscreens!

The author of this article, Jack Royans (then 19), enlisted in the Empire Air Training Scheme during WWII. After completing an operational tour of duty on Wellingtons he was posted to instructional duties as a Flying Officer. After the war, he returned to his clerical job with the South Australian Railways in Adelaide. →

B.A.S.H.

THE USAF BIRD CONTROL PROGRAM

Condensed from an article featured in the April 1997 edition of USAF *Flying Safety*.

AFTER this last winter, I'm sure we're all looking forward to the return of springtime and warmer weather. While this is a welcome thought, we must remember the change of seasons means different things to different people. If you're involved in airfield safety, this means it's time to blow the dust off your BASH plan and get it ready for the spring migrations. 'BASH plan?' you say. 'What is a BASH plan?'

The crash of the E-3 AWACS aircraft at Elmendorf AFB, Alaska, 22 September 1995, brought renewed interest in all things BASH. For the uninitiated, the acronym BASH stands for Bird Aircraft Strike Hazard.

The successful plan

Frequently, the USAF BASH Team at the Air Force Safety Center is asked, 'What does it take to make a successful BASH plan?' To be honest, a good BASH plan shouldn't require the skills of a brain surgeon or even a Ph.D. in wildlife biology. While it's wise to consult with a member of the BASH team before undertaking any program, a base can have a successful BASH plan if they keep a few simple things in mind.

No matter how well managed the control plan, it's impossible to completely control all birds and wildlife on an airfield. If you're successful in relocating one target population of wildlife, another will most likely take its place. Hopefully, the newcomer will be less hazardous or more easily controlled.

For example, if you allow your infield turf to grow taller to discourage flocking birds, you may see an increase in rodents which may, in turn, attract predators such as coyotes. Although coyotes have been struck by aircraft on take-off roll and are thus a hazard, they are more predictable and controllable.

Now that we understand species composition around the airfield may change as a result of a successful control operation, we must next keep in mind that seasonal changes may also necessitate adjustments to the BASH plan. For example, a base may experience problems with gulls during winter months and smaller flocking birds in the summer. The gulls may migrate into the area during the winter to feed at a local land fill and be gone by spring, at which time small flocking birds may move into the area to feed behind mowing machinery. Just remember the problem will dictate the solution.

Finally, for a plan to be successful, it must have a clear protocol, personnel support, and a commitment to implement the plan with vigilance.

Four-legged hazards

A point of clarification: a BASH plan shouldn't be limited to birds alone. Although birds provide the greatest hazard to aircraft, any animal on or near a runway area creates the potential for catastrophe. Deer often weigh in excess of 50 kg and can ruin a pilot's day if struck. And remember - they are most active after dark when they are difficult to detect. (In Australia, kangaroos are generally larger and provide as significant a hazard on the more remote airstrips. - De).

Smaller burrowing animals, such as woodchucks and prairie dogs, have undermined pavements, VAS bases, and safety areas.

Woodchucks have caused runway blackouts by gnawing through underground wiring. Beavers have flooded airfields by damming drainage ditches. Small field rodents frequently attract larger predators to safety areas, such as hawks and coyotes, and so on. The point here is BASH is more than birds, and airfield managers

should pay close attention to all wildlife sightings on the airfield and respond accordingly.

An animal's perspective

By now, some of you may be wondering why significant numbers of wild animals would be found around an airfield when there seem to be more hospitable choices elsewhere. Most would agree an airfield is a noisy place teeming with lots of activity arising from the frequent movement of large, jet-powered machinery. One would think timid denizens of the field and forest would have nothing to do with such a piece of real estate. Not so!

As you look at your airfield from a BASH perspective, keep in mind the recurrent theme from the movie *Field of Dreams* – if you build it, they will come. This same rule applies to your base. If the airfield provides habitat, wildlife will come. Viewed from the perspective of an animal in the wild, an airfield has much to offer.

Airfields are normally surrounded by large expanses of open area to facilitate an additional margin of flight safety. In addition, most airfields are fenced to reduce inadvertent entry. As it's desirable to land on relatively flat surfaces free of standing water, it's necessary to provide storm-water capacity via retention basins and drainage ditches. As wildlife see it, the only visitors to these secluded, fenced-off grassy areas of ditches and ponds are usually operators of mowing machines who generally pose no threat. However, they leave behind lots of goodies, like mowed straw for nest construction and shattered seed heads or maimed insects for food. When one considers these points, there's little wonder why many wild animals call your airfield a refuge. All the food, water, and potential shelter, enclosed by a fence to keep out humans and their pets, is worth the risk of being struck by an aircraft.

The mechanics of the plan

Now that we are all up to speed on some basic ground rules, let's look at the mechanics of a general BASH plan. If you don't have a clue about what a BASH plan looks like, a sample plan may be obtained by contacting the BASH Team at the US Air Force Safety Center. Next, you should obtain a copy of your base's bird strike data profile from the BASH Team. Also, talk with base operations to see whether they have been keeping logs of their runway checks. Find out if they have been responding to any wildlife activity or when bird watch condition codes have been listed as moderate or severe. These two bodies of information can shed light on the

kind of wildlife present on base and when they are creating hazardous conditions.

If these sources of information don't provide enough information, the base may choose to contract a wildlife biologist who specializes in the field of wildlife damage control.

Bases have two contract choices. They may either choose to deal with a private company or a government agency. Regardless of the choice, the contractor should

have a good background in wildlife control and be able to perform an ecological study to establish a base line of wildlife activity that could be hazardous to aircraft. The United States Department of Agriculture (USDA) has an Animal Damage Control (ADC) program that has agreed to provide different

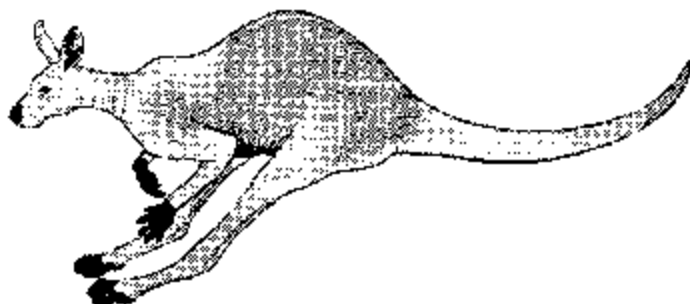
levels of assistance through a signed Memorandum of Understanding (MOU) with the Department of Defense. This MOU allows the USDA to provide different levels of assistance from a cursory technical assistance visit to a contracted fully operational wildlife control program.

This base line, or wildlife profile, is primary to the development of a successful BASH reduction program. The type of wildlife on or near a base and the habitat that's being used are what drive a program. Once these components are identified, you can then begin to assemble the respective parties who may be able to effect a change to the habitat the wildlife are using. These 'respective parties' will become the members of your Bird Hazard Working Group (BHWG).

The working group

By regulation, the BHWG is supposed to meet at least twice a year. Can they meet more than twice a year? In a word, absolutely! The BHWG is chaired by the vice wing commander and normally comprises all those who have anything to do with airfield, operations, safety, and, of course, bird control. As a minimum, this group should include a representative from Civil Engineering (CE), Environmental, AIC, Airfield Management, Safety, and Security. Minutes are required to be maintained for every meeting.

Although they seem to be from unrelated fields, it is necessary for these individuals to attend BHWG meetings to openly discuss issues. For example, if the operations staff has frequently harassed birds away from an unmowed area near the north end of the airfield, CE may be asked why the area is not being maintained. The engineer may explain this area is holding water and can't be drained. Why? Because it is currently under investigation by the environmental staff as to whether or not it



should be classed as a wetland and thus protected. Because the environmental staff is present, they may then discuss options available to the base to reduce the attraction to the area. One can quickly see why such meetings are so important to a bird hazard reduction program.

We're not quite there yet

Let's say you have become more enlightened about the regulations, have a good base line of wildlife activity due to surveys and good record keeping, and you are maintaining an open line of communication between all responsible parties. Does this mean you have a good BASH reduction program? Not quite. Just because you have blueprints doesn't necessarily mean you have a house. There are a few more things to consider.

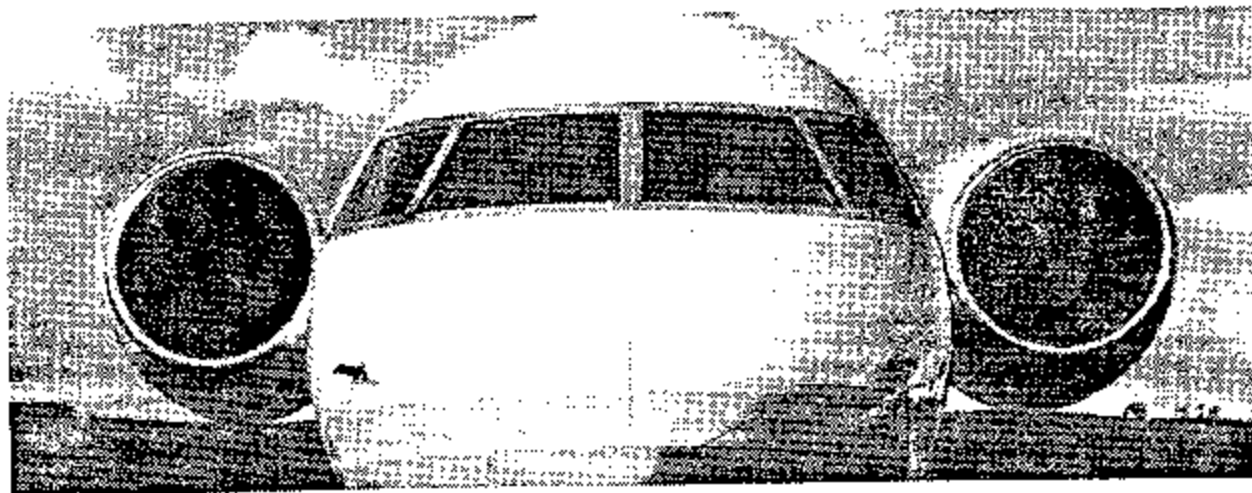
Probably the most important part of a BASH reduction program is implementation — often the weak link in a good chain. It's absolutely necessary to have a sound

If the airfield has been well drained, made as uniform and unattractive to wildlife as possible, and a few wild non-believers still remain, then it's tool time.

Your tool box

The first tool many base BASH programs include in their wildlife control tool box is the propane cannon. Most expect far too much from a propane cannon. They place it in too large an area and set it to fire too frequently. Wildlife are accustomed to noise on an airfield, and cannons repeatedly going off do not affect them. Propane cannons require active management and serve to reinforce other harassment techniques.

Live ammunition should be part of your control program if it's legal for use. Studies at John F. Kennedy International Airport have shown conclusively that shooting is effective in reducing wildlife hazards to aircraft. If you're not occasionally shooting birds where



protocol spelling out how you will react to wildlife activity near the airfield and who is going to respond. Since you're now keeping good records, you should be able to look back and, based on past history, 'predict' when wildlife activity is greatest. This should give you a clue as to when to have your personnel ready for action. If your base records are lacking, go back to your strike data obtained from the BASH team.

You may be beginning to think you have all your bases covered, right? Not yet. Just because you have all your information going in the right directions and you have a reliable person ready to respond, does this person have the right tools?

Before we get into the tool department, let's back up just a bit. We should keep in mind the first line of defence should be to try to alter the habitat the birds or other wildlife are using.

This could mean mowing the airfield to the recommended height or keeping drainage ditches open and free of tall vegetation. Another good rule of thumb for airfield maintenance is if it sticks up and isn't fixed by a function, then have it removed.

and when legally possible, you're reinforcing a behaviour of ignoring the sound of gunfire (propane cannons and pyrotechnics). However, one must never shoot live ammunition before making sure all questions of legality are answered.

One thing specifically required prior to using live ammunition to control birds is a depredation permit. This permit is issued by the US Fish and Wildlife Service (FWS). The FWS will usually request you contact the USDA ADC specialist in your area to review your current program. They want to ensure no threatened or endangered species present on the base will be at risk and that other attempts at controlling wildlife have met with less-than-desired results.

If you are successful in reducing the numbers of birds on the airfield through depredation, you should try to learn as much as possible from them. By performing a necropsy (a fancy word for cutting them open), you may be able to identify the food source attracting the birds to your airfield. If you have problems performing a necropsy, specimens may be frozen for later inspection by a BASH team member or a USDA biologist.

CLOSE ENCOUNTERS OF THE BIRD KIND

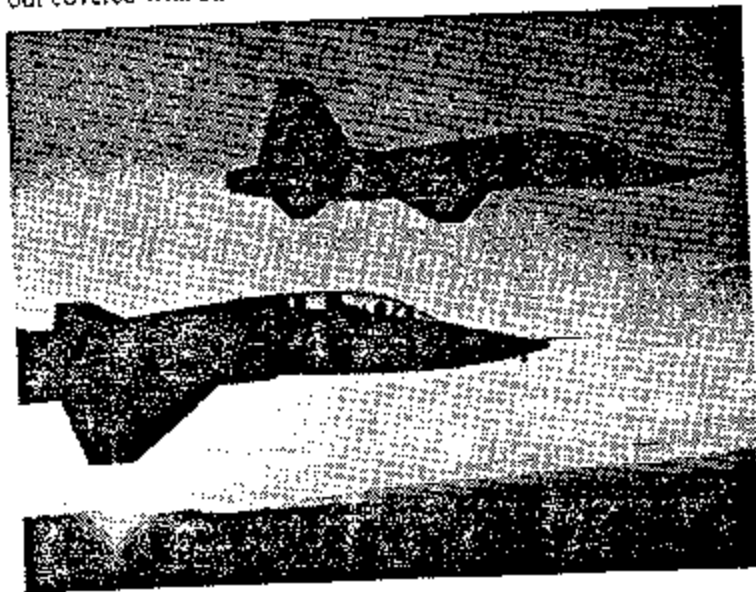
by Captain Joe Becker, USAF

PASSING 7 400 ft at 300 kts I saw a brown flash right in front of the upper windscreen rail. The flash barely registered when my canopy and the bird smashed into me. My head snapped back against the seat, my visor and oxygen mask mashed my face, and the canopy came crashing into my chest.

I was taking a student on his first T-38 cross-country. The second leg of our instrument ride was from Eglin to Little Rock and I decided the student would get better training in the back seat under the hood.

We took off from Rwy 18 at Eglin and were climbing on runway heading. Passing 5 000 ft, I took control so the student could pull the hood forward. Still southbound a few miles off the coast and hoping for turn back to the north, we got our surprise guest.

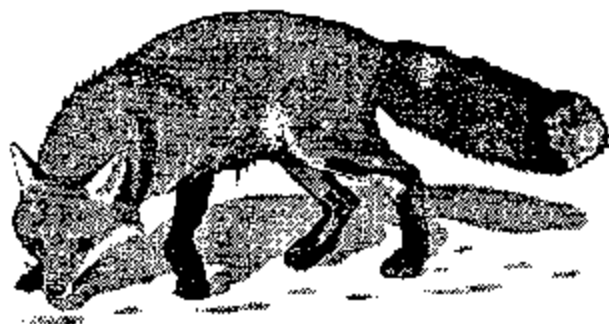
Fortunately for us, the pressure differential was close to equal so there was no decompression. I couldn't see very well because of the bird pieces on my visor, but I wasn't about to raise it. I checked the engine instruments and the master caution panel to see how my jet was doing. Both engines appeared fine, but some of the pieces of the canopy still in the frame were falling out. I tried moving my arms and felt pieces of the canopy on top of them, so I slid the pieces off the sides of my seat and turned north toward Eglin. I dialed in 7700 on the IFF and selected 100 per cent oxygen. The wind rush was noisy, but there was no air blowing directly on me and the aircraft seemed to be handling fine. In the turn, I shouted at my student and adjusted one of the mirrors so I could look at him; he was moving around and the windscreen separating front and rear cockpits was intact but covered with bird matter.



On impact, the student had the instrument hood all the way forward. As briefed, he pulled the hood back and saw the now 'convertible' front cockpit. He shook the stick to make sure somebody was flying because he didn't know yet if I was hurt; I shook him off on the stick to let him know I was flying the aircraft and tried telling him my intentions. We couldn't hear each other or anyone else (such as Approach), with the wind blasting through the shattered canopy. I told Approach we couldn't hear them, we had an emergency, and we were turning back north direct to Eglin for a visual straight-in to Rwy 19. The student, unable to hear me, also made radio calls in the blind.

We were VMC below any weather when the bird strike occurred so I could spot the airfield. Both of us kept transmitting our intentions to Approach. When we got below 3 000 ft on downwind I switched to Tower and transmitted our status and intentions. We had routinely briefed the localiser approach as our emergency return plan and here we were doing it! I levelled off at 1 500 ft and slowed to configure. Below 200 kts the student and I could finally hear each other if we shouted. We confirmed our approach speeds and configuration and full-stopped on Rwy where the rescue crew met us.

This story has a happy ending. Both the student and I were fine and the aircraft only needed a new right engine and canopy. Several factors contributed to this happy ending. Some were outside our control: good weather, minor damage to the engine, the angle at which the bird broke through the canopy. We had done our best, however, to maximise our chances of survival by preparing for those factors we could control. We did a thorough brief about our emergency return option and were well prepared when we needed to execute our plan.



Other harassment techniques

What about those other techniques? It's often recommended broadcasting taped bird distress calls. Distress tapes can be effective, but they must be used properly. To get certain birds to respond, you must use a distress call tape recorded from that species of bird. In other words, gulls will not respond to blackbird distress calls.

Another thing to remember is birds will respond differently to distress calls. When gulls hear another gull calling in distress, they will usually take flight and investigate the source of the call. Blackbirds, on the other hand, will take flight, circle a bit, and leave the area. Knowing this can be very useful. If you want to move gulls away from the end of the runway, don't park your vehicle there to broadcast a gull distress call. It's recommended you park in an area where you can safely disperse the birds with pyrotechnics or use live ammunition to shoot a few.

There goes one of those \$20 words again! What are pyrotechnics? Simply industrial or agricultural fireworks. Pyrotechnics include shellcrackers, bird bombs, and screamer sirens. These devices are probably the most widely used wildlife harassment tools on the market today. They are safe, readily available, inexpensive, non-lethal, and normally don't require a permit for use. Recent rulings by the US Air Force have authorized the purchase of these devices and their launchers. However, they would be illegal to use around birds actively occupying a nest site or around threatened or endangered species.

Another technique useful in reducing wildlife strikes is avoidance. If there are large, known movements of birds (such as migrations during Spring and Autumn), you may choose to schedule flight operations around these well-known periods of bird activity. The BASH team recommends low-altitude flying be restricted one hour before and after sunset during increased bird activity. Before scheduling low-level flights, areas of known bird activity may be avoided by contacting the BASH team and having the desired routes checked against our Bird Avoidance Model, or BAM. The BAM plots known waterfowl movements by season of the year to give a prediction of bird activity for specific routes. The BASH team is currently revising this model by employing GIS techniques to include more data fields to provide schedulers up-to-date information.

What we need from you

After providing all this information, we at the BASH team would like something in return. To better serve our bases, we need to know everything possible about your individual bird strikes. If you revisit the regulations, specifically AFI 91-204, you'll find a section for wildlife strike reporting. This regulation spells out the information we need to maintain our database. It's important to note here that all wildlife, not just birds, may be reported to us. The reports come to us via AF Form 853. This form has recently been computerized for convenience, and we will now accept your monthly strike reports via the Safety Center Bulletin Board. This reporting system allows us to easily track wildlife hazard trends as shown in the accompanying charts.

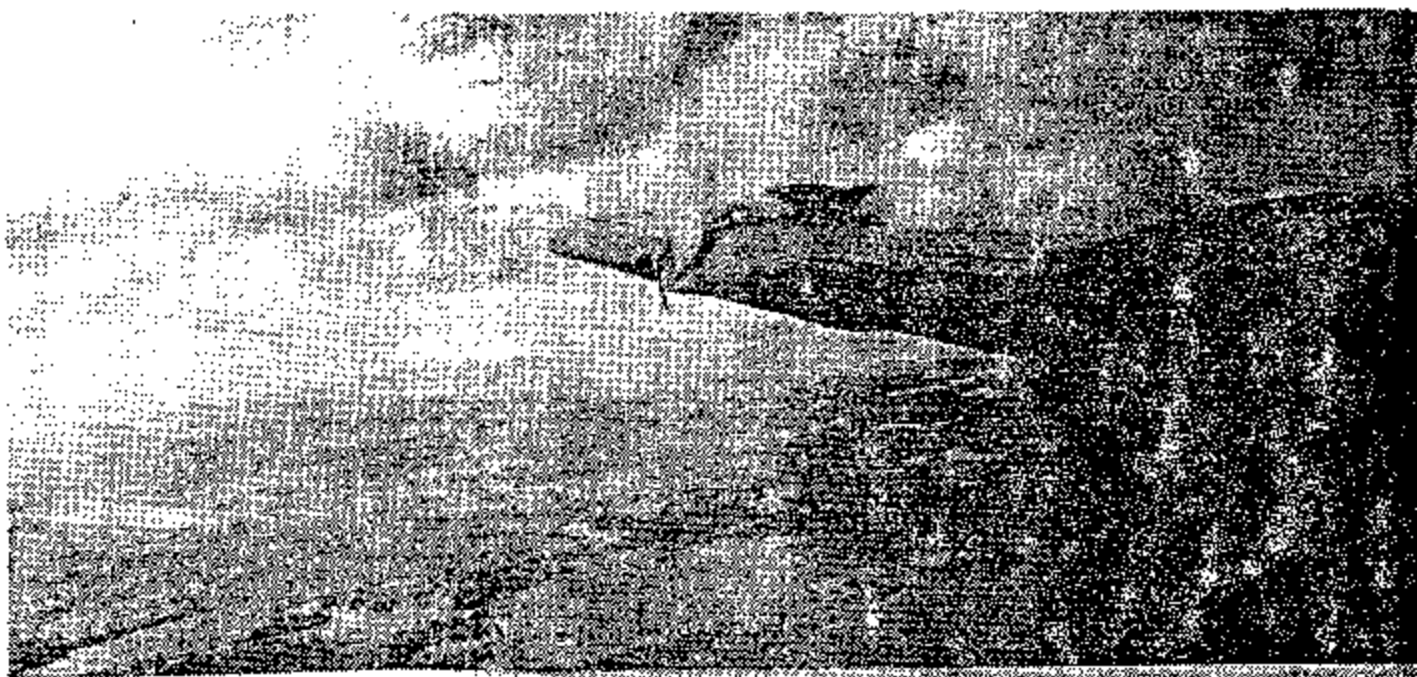
When submitting reports, do not forget to collect whatever non-fleshy bird remains you may find and forward them to the BASH team at Kirtland AFB. Even if you are positive of the bird's identification, you must always send a sample to the team. On more than one occasion, we have had to change an incorrectly identified bird type in our database after proper analysis. As a service we provide to all bases, we will have the remains properly identified by contract specialists at the Smithsonian Institution in Washington DC. Once we have an accurate identification, we will inform the base of the bird type. This information is important as the bird type will often dictate where control efforts may be best directed.

One step at a time

All this information may seem a bit overwhelming when considered all at once. However, once you get underway and take it one step at a time, you will see that most of these recommendations rely on good old commonsense. The key is you must remain flexible with your approach because if you are successful in removing one species, another will likely move in to fill the void. The idea is to manage the wildlife population down to a number and type of species less hazardous to your specific operation. Always remember no program will ever completely eliminate all wildlife from an airfield or achieve the desired results unless properly implemented through perseverance.

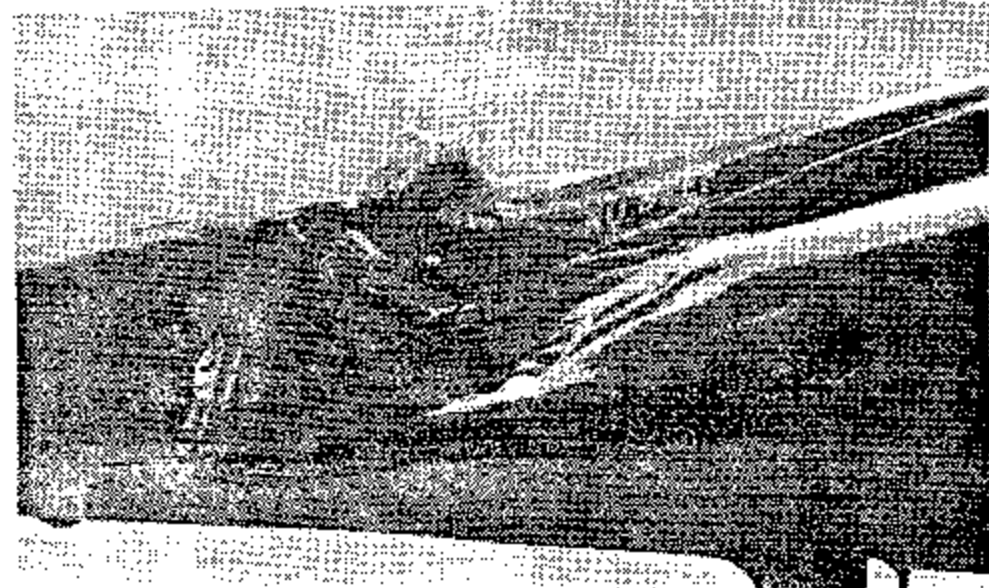
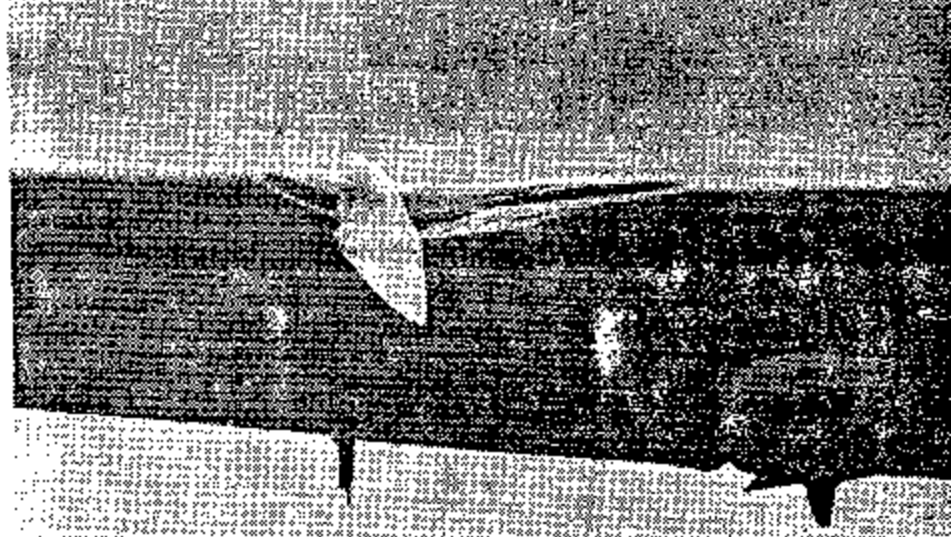


BIRDSTRIKE



*A CARIBOU FLYING AT
115 KIAS AT 500 FT AGL
SUSTAINED A PELICAN
STRIKE.*

*THE PELICAN REMAINED
ATTACHED WITH ITS
LOWER BILL INFLATED
BY AIRFLOW.*



RESULT:

*SEVERE BUFFETING AND
ONE THIRD AILERON
DEFLECTION TO INITIALLY
MAINTAIN CONTROL.
CONTROLLABILITY INCREASED
WITH LOWER AIRSPEED
CATEGORY TWO DAMAGE*

APPENDIX 36

**The Globe and Mail, Thursday, November 6, 1997:
How lake birds are making a comeback**

How lake birds are making a comeback

CONSIDER the relationship between science and that most famous of working birds, the canary in the coal mine.

Canaries, of course, are especially sensitive to carbon monoxide; in the old days, miners knew that when the odourless, deadly gas knocked the birds off their perches, they still had time to escape with no more than a headache.

More recently, people living around the Great Lakes may have felt like miners when the gulls, terns, cormorants and other water birds around them went into a steep population decline in the 1970s. Not only were the birds dying, those that survived were not reproducing at their natural rates.

The cause of this havoc was immortalized in naturalist Rachel Carson's famous book *The Silent Spring*. So many lethal chemicals such as DDT, mercury, PCBs, dioxins and furans had seeped — or had been dumped — into the lakes that birds were laying eggs either with shells too thin to protect their contents or were producing offspring too deformed to survive.

The population declines were dramatic and frightening. The number of nesting pairs of the double-crested cormorant throughout the Great Lakes fell from 900 in the early 1950s to 125 in 1973. In the same year, the once-common osprey was represented in Lake Huron's Georgian Bay area by a single pair nesting atop a hydro-electric pole. Meanwhile, a biologist visited Scotch Bonnet Island in Lake Ontario and found that only 17 of 100 herring-gull nests contained chicks.

The great fear was that the birds' fate would be that of us all. So Canada and the United States launched a joint campaign to make sure the pollution reaching the lakes would be cut deeply and a network of public and private agencies monitored the process closely.

A quarter-century later, the results have been so dramatic that scientists like Chip Weseloh, head biologist with the Canadian Wildlife Service in Toronto, find it difficult to persuade the public that things have changed.

In recent years, he and his Environment Canada colleagues have published their findings under such titles as *The Rise of the Double-Crested Cormorant on the Great Lakes: Winning the War Against Contaminants* and *The Fall and Rise of Osprey Populations in the Great Lakes Basin*. (To see their work, visit the CWS web site at <http://www.cwsc.ca/green-lake/wildlife/>)

Even so, "I still get people saying, 'You mean things are better than they used to be?'" says Dr. Weseloh, who specializes in the effect of chemicals on water fowl. "And they are absolutely amazed when I tell them they are. And I am absolutely amazed that they don't know it."



R in D

Stephen Strauss

What has the research discovered? First, the latest figures suggest that within 20 years the 125 nesting pairs of cormorant (a big, black fish-eater) had produced a population of no less than 38,000. "The cormorant is now more numerous on the Great Lakes than in any time in previously recorded history," according to an Environment Canada fact sheet.

As for the osprey, since the mid-1970s, its population has been increasing at an annual rate of 7 per cent in Michigan, 8 per cent in Wisconsin and 10 to 15 per cent in southern Ontario. Compared with 1973's lone breeding pair, Georgian Bay now has 50.

Meanwhile, by 1990, the number of ring-billed gulls had risen from 190,000 in 1978-79 to 420,000.

Indications are that in all these cases the totals have continued to rise since the last surveys were taken. However, the news is not universally good: Both the common tern and the Caspian tern have not experienced a population explosion, leaving scientists to wonder why.

Still, if the birds of the Great Lakes really are early harbingers of waterborne danger to humanity, what conclusions can be drawn from their relatively rapid recovery?

It may be that enough has been done to clean up the Great Lakes. As Dr. Weseloh notes, what you find in wildlife science often depends on when you look. Had for some reason a systematic surveying of the water birds not begun before the chemical levels were cut, scientists may well have missed seeing just how disastrous chemical effects on wildlife can be. "By the end of the 1970s," he says, "the worst was over."

In a very subtle way, the experience of the Great Lakes' bird population may demonstrate the scientific limitations of watching canaries in coal mines.

For example, the total amount of various pollutants have fallen anywhere from 70 to 90 per cent, but some toxins still remain. Scientists now wonder what affect these reduced amounts will have on the wildlife population — such as its life span, hormone levels and ratio of males to females. But monitoring overall population levels is unlikely to be of much help with such complex issues.

So, it may be too soon to speculate that the danger is over. But by the same token, there is no absolute guarantee that the chemicals caused the problem in the first place. Nature is tricky and science limited to the evidence on hand, so it's still possible that some other factor — a natural drop in reproductive cycles, some undetected virus, something in the water that wasn't even measured — is the true culprit.

Questions remain unanswered. Why have the populations of Caspian and common terns actually dropped in certain locations since the water began to improve? Perhaps they were simply pushed out of their breeding grounds when all the other birds bounced back to such a great degree. Or perhaps they, rather than their more robust cousins, somehow provide a truer measure of what's happening in the Great Lakes waters.

The monitoring goes on, but in the final analysis, even things that seem definite and absolutely "scientific" are just inference. As French psychologist Claude Bernard once put it: "The experimenter who does not know what he is looking for will never understand what he finds."

Research in Development by Globe and Mail science reporter Stephen Strauss appears every Thursday and may be reached by E-mail (ss Strauss@GlobeAndMail.ca), telephone (1-800-461-3299 toll-free or 1-416-585-5168), fax (1-416-585-5085), and by writing c/o The Globe and Mail, 444 Front St. W., Toronto, Ont., M5V 2S9.

APPENDIX 37

Aerodrome Safety Information Circular, December 19, 1997



Transport Canada
Safety and Security

Civil Aviation

Transports Canada
Sécurité et sûreté

Aviation civile

TP 13029

ASIC No. / N° de CISA	97-002
Date	December 19, 1997



Aerodrome Safety Information Circular

Circulaire d'information de la Sécurité des aéroports

BIRD HAZARD WEBSITE AND TOLL FREE REPORTING NUMBER

PURPOSE:

This Aerodrome Safety Information Circular is being issued in order to advise Canadian Aerodrome operators of two new services that are available for the reporting of bird and mammal strikes.

BACKGROUND:

In order to maintain its database on bird/wildlife incidents, Transport Canada has depended on a voluntary system whereby pilots, airlines, aerodrome operators, and DND have provided data in a number of formats. In order to enhance the data collection system, Transport Canada has recently initiated two new systems for reporting bird/wildlife incidents or accidents. A toll-free number (1-888-282-BIRD) is now available so that anyone who becomes aware of a bird/wildlife incident or accident can easily provide a report to Transport Canada.

In addition to the toll-free number, Transport Canada has also developed a bird hazard website :

(www.tc.gc.ca/aviation/wildlife.htm).

SITE WEB SUR LE PÉRIL AVIAIRE ET NUMÉRO SANS FRAIS

OBJET :

Cette circulaire d'information relative aux aéroports vise à informer les exploitants d'aéroports canadiens de deux nouveaux services auxquels ils ont accès lorsqu'ils désirent rapporter des impacts d'oiseaux et de mammifères.

CONTEXTE :

Afin de maintenir cette base de données sur les incidents liés aux oiseaux ou à la faune, Transports Canada fonctionne sur la base d'un système facultatif dans lequel les pilotes, les entreprises de transport aérien, les exploitants d'aéroports et le MDN fournissent des données sous différents formats. Afin d'améliorer la collecte de données, Transports Canada a récemment instauré deux nouveaux systèmes pour rapporter les incidents ou les accidents liés aux oiseaux ou à la faune. Toute personne qui est témoin d'un incident ou d'un accident lié à aux oiseaux ou à la faune peut facilement le rapporter à Transports Canada en appelant au numéro sans frais (1-888-282-BIRD).

En plus de ce numéro sans frais, Transports Canada a créé un site Web sur le péril aviaire:

(www.tc.gc.ca/aviation/wildlife.htm).

This new site not only allows on-line reporting, but it also provides access to Transport Canada's bird/wildlife database, the Wildlife Control Procedures Manual, and awareness/education material.

INFORMATION:

In order to minimize bird and mammal hazards to aircraft, Transport Canada requires a complete and accurate database of incidents and accidents. It is hoped that the implementation of a website and toll-free reporting line will make it easier for stakeholders to provide reports, which should allow Transport Canada to focus its resources on those areas which require improvement. For further information please contact:

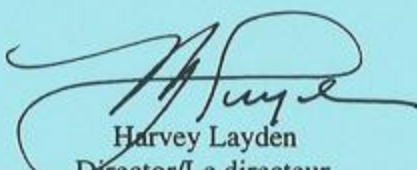
Bruce MacKinnon
Wildlife Control Specialist
Transport Canada, Safety and Security
Aerodrome Safety Branch
330 Sparks St., Place de Ville, Tower C
Ottawa, Ontario, K1A 0N8
Phone: (613) 990-0515 Fax: (613) 990-0508

Ce nouveau site permet non seulement de faire des rapports en direct, mais d'avoir accès à la base de données sur les oiseaux et sur la faune de Transports Canada, au *Manuel des procédures sur la gestion de la faune* et à des documents de formation et de sensibilisation.

INFORMATION :

Afin de minimiser le péril lié aux oiseaux et aux mammifères, Transports Canada a besoin d'une base de données d'incidents et d'accidents précise et complète. Nous espérons que la création du site Web et du numéro sans frais aidera les intervenants à fournir des rapports, ce qui devrait permettre à Transports Canada de concentrer ses ressources aux secteurs qui ont besoin d'être améliorés. Pour de plus amples renseignements, communiquez avec :

Bruce MacKinnon
Spécialiste du contrôle de la faune
Transports Canada, Sécurité et sûreté
Direction de la sécurité des aérodrômes
330, rue Sparks, Place de Ville, Tour C
Ottawa (Ontario) K1A 0N8
Téléphone : (613) 990-0515 Télécopieur : (613) 990-0508



Harvey Layden
Director/Le directeur
Aerodrome Safety/Sécurité des aérodrômes

APPENDIX 38

**FAAviationews, Nov./Dec. 1997:
Canada Geese: Flying Elephants We Must Avoid!**



Canada Geese: Flying Elephants We Must Avoid!

by Sandy Wright

Canada geese in holding area at National Wildlife Research Center in Sandusky, OH. They will be released after the goose repellent tests are completed. (P. Wright photo.)

INTRODUCTION

A flock of Canada geese honk as they pass overhead in their familiar "V" formation. Many of us would be stirred by this sight. However, if you are a pilot who had a run-in with one of those eight- to 12-pound birds, you might see them in a different light. Each year an average of 60 goose strikes is reported to the FAA, but in all probability, there are another 240 that are not reported, based on FAA statistics. Most goose strike reports (85%) do not identify the species. Canada geese, snow geese, and brant represent 92%, seven percent, and one percent of the strikes that are identified to species.

BIOLOGY

The Canada goose is distinguished from other geese by its black neck and head with a white cheek patch. The body feathers are gray-brown to dark brown. Because there are several

subspecies, it is impossible to give an exact weight but they range in size from three to 12 pounds. Their life span is about eight years. Geese are monogamous and work together to raise their young. The usual hatch is about five young. In late June and early July, the adults are unable to fly because they are molting, and the young have not acquired their flight feathers. But by late July, all the family can fly, and they congregate in large flocks and move to open areas where there is abundant food. Geese are attracted to airports because of the grassy expanses devoid of trees and shrubs. They feed on tender grass, clover, and grains.

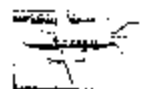
POPULATIONS ON THE RISE

Canada geese are among the most numerous and diverse of all waterfowl species in North America. The non-migratory population has increased from about 0.2 million to 1.8 million (800%) since 1970 (Figure 1). The number of

Canada geese migrating through North America has increased from 1.8 to 3 million (57%) since 1970 (Figure 2). The winter distribution of these migratory geese has changed over the last 40 years because of wildlife management practices or providing food for the geese throughout the winter. Now many flocks are remaining in northern areas in winter, and the migration patterns are not as clear as they once were. These increasing populations of migratory, and especially non-migratory geese, coupled with the growth in air travel, both commercial and private, set the stage for a greater chance of collisions between aircraft and geese.

DEVASTATING AND COSTLY STRIKES

Nearly 50% of all strikes with geese involve some degree of damage and at least 24% have an effect on the flight. A low high profile accidents in the United States have recently brought



attention to this growing problem. In June 1995, a Concorde, on final approach to JFK International Airport, struck several geese which destroyed two engines. No one was injured, but the damage totaled about \$6 million. Three months later, in September, an Airbus 320 struck Canada geese at La Guardia. The repair bill along with loss of revenue came to over \$2.5 million. In December 1996, a B-747, on approach to JFK International, had an expensive goose strike. Snow geese destroyed two engines and damaged the airframe to the tune of \$6 million. The crew said it felt like the aircraft was being struck by sandbags.

The most devastating strike with Canada geese to date happened at Elmendorf Air Force Base (Alaska) in September 1995. Twenty-four military personnel were killed when their E-3 AWAC aircraft (a modified Boeing 707) crashed after striking a flock of Canada geese on takeoff. Along with the tragic loss of lives, a staggering cost of \$189 million was incurred. A few days later, in Michigan, U.S. House Speaker Newt Gingrich's plane struck geese on take-off. There were no injuries, but the aircraft overran the run-

way during the aborted take-off.

THE FORCE OF AN ELEPHANT

Large birds are the greatest threat to aircraft because the force of the impact is affected by the bird's weight and the speed of the aircraft. Geese can weigh as much as 12 pounds. According to Transport Canada, the impact of a goose striking a jet can be equal to 1.5 million foot pounds of energy, a force equal to that of an African elephant stampeding over a parked car. Most of today's commercial airliner jet engines can withstand the shock of a one and a half pound bird, and the newest airliner jet engines have been designed to take a two and a half pound bird without failing. Aircraft frames and engines are not built to withstand striking a single goose let alone a large number of geese at high speed.

AVOIDING GOOSE STRIKES

In order to avoid damaging strikes you should be aware of when and where these strikes are likely to occur. The worst months seem to be March

(14%) and August through November (45%) (figure 3). The most likely phase of flight for strikes is approach (40.2%). Light conditions seem to favor day/dawn at 46%. Goose strikes have been reported in 42 states. Illinois had more goose strikes than any other (5.7%), followed closely by Connecticut (3.3%) and California (3.0%). The northeastern part of the U.S. seems to be heavily represented with four states and the District of Columbia equaling 30% of the total goose strikes reported. More strikes occur on the runway (altitude 0) than any other altitude. If you observe geese on or near the runway be extremely cautious. Request that the geese be cleared from the runway area and do not land or take off until they are gone.

WHAT IS BEING DONE TO CONTROL GEESE?

Scare Tactics

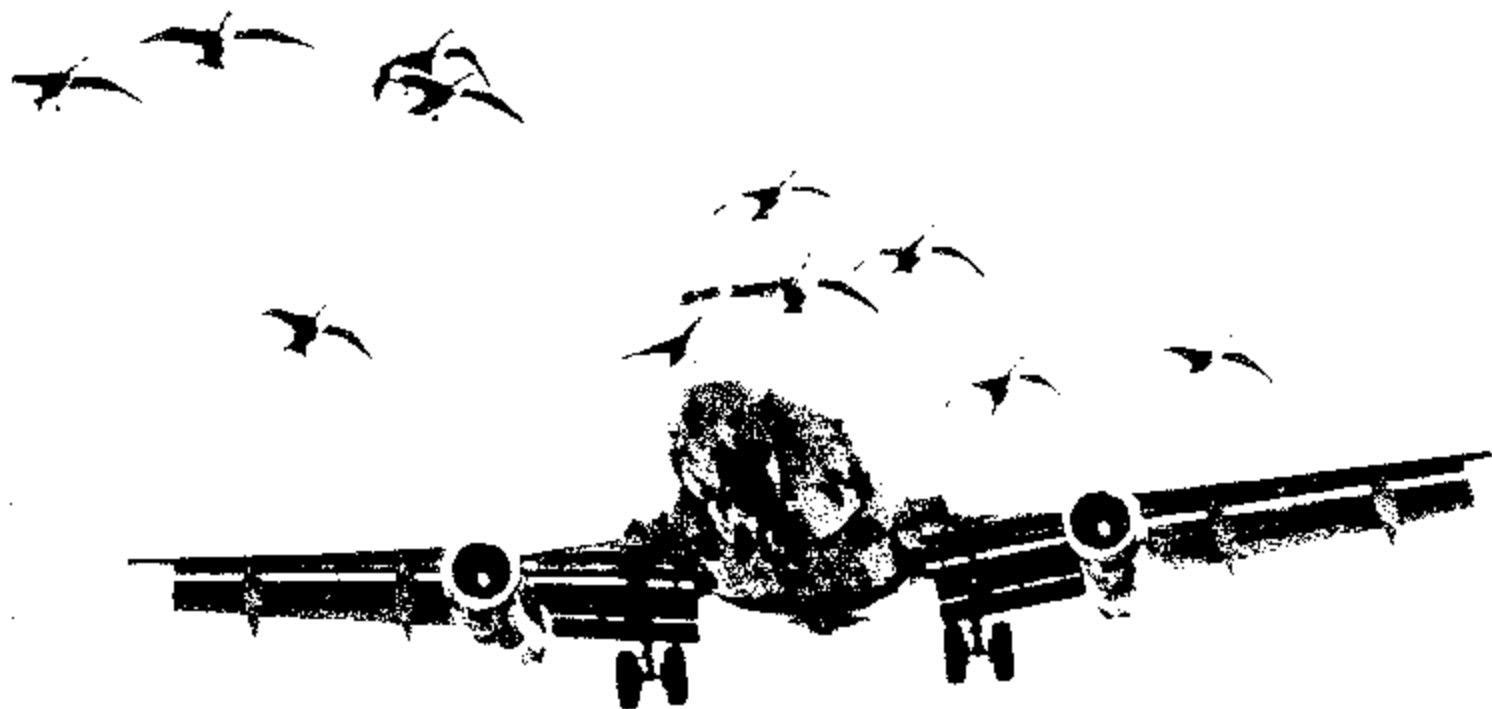
Presently, complex Federal and State responsibilities are involved with Canada goose control activities. All actions, except harassment, require a Federal permit and in most cases a state permit is also required. Wildlife Services (WS) biologists from the U.S. Department of Agriculture are assisting airport managers with the management of geese in the vicinity of airports.

Your strike reports help bring this problem to their attention. For example, an airport in Missouri had a strike reported when a twin engine aircraft received damage to one wing when it struck a goose. WS biologists found 300 geese feeding in crops adjacent to the runway. The geese were harassed with pyrotechnics, and some were removed.

Sometimes geese can be discouraged from taking up residence by the use of noise making devices such as shell crackers—special shells fired from a 12 gauge shotgun that project a firecracker up to 125 yards—and auto-explosors which produce a sound similar to that of a shotgun and which can be set up to go off automatically. Distress calls are also played to frighten the geese away. After a while,

Inspecting engine damage from a goose strike. (R. Dolbeer photo.)





the geese become used to scare tactics and are not affected by them.

Relocation and Removal

Geese are sometimes removed from the site and relocated to a more desirable area. Officials at Washington

National and Washington Dulles International airports were unable to completely remove geese by harassment techniques. WS, with the assistance of the Virginia Department of Agriculture, obtained the necessary permits, captured 1,098 resident geese during the summer molt when the birds were

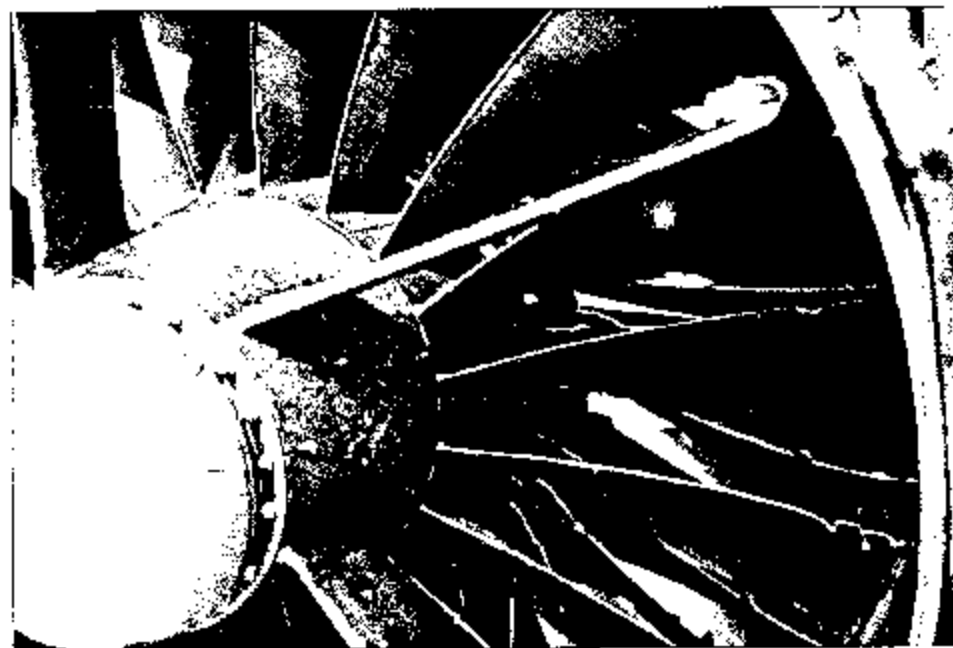
flightless, and relocated them to the Tidewater region of Virginia.

Habitat Management

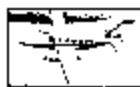
Habitat management is another way to prevent unwanted species from using airport grounds. Research has shown that geese tend to avoid areas where the grass height is over four inches. Tall grass height, combined with an active harassment program, should dramatically reduce a goose population.

In 1996, the National Wildlife Research Center studied the effect of lime applied to grass as a deterrent to geese and found that it was an effective repellent. More studies are planned to determine the minimum effective concentrations of lime on turf and agricultural crops.

Recognizing the threat posed to aircraft by wildlife, the FAA is curtailing the growing of crops on airport prop-



A close up of an engine damaged by Canada geese. © Dalseg photo.



**RESIDENT (NON-MIGRATORY) CANADA GOOSE
POPULATION IN NORTH AMERICA, 1970-1995**

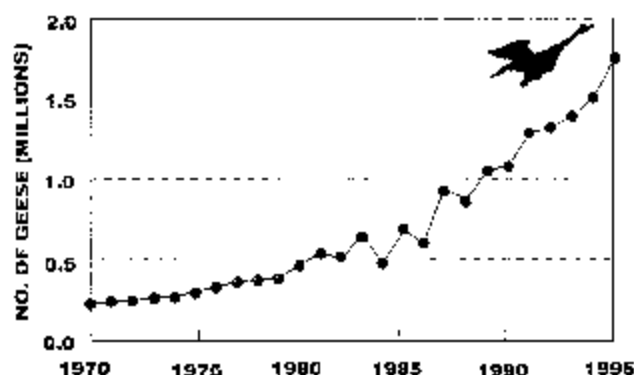


Figure 1

**NO. OF AIRCRAFT COLLISIONS WITH GEESE
BY MONTH 1989-1996**

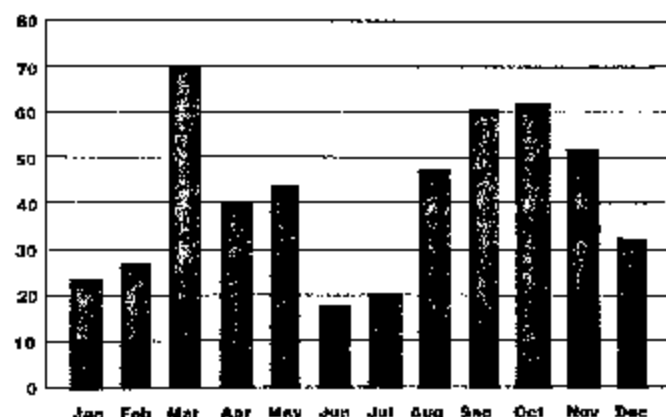


Figure 3

erty. Unfortunately this is being met with opposition by some airport managers who think that it is futile since "birds will be around regardless of what they do." However other managers, including a former military B-52 pilot, support the FAA saying, "I know what a goose can do to an engine. When I was in the military farming operations were not allowed around military fields."

REPORT ALL STRIKES

Wildlife strike reporting is critical to managing this serious problem because the accuracy of FAA analyses and the ability to provide appropriate recommendations are limited by data availability. When you file a wildlife strike report, it is entered into the FAA Wildlife Strike Database. The FAA estimates that less than 20% of all strikes

are reported. If airport managers and wildlife biologists are to control the bird strike problem they must have accurate data on which to base their actions. These data come from FAA Form 5200-7 "Bird/Other Wildlife Strike Report" which was updated this year and is available from local Flight Standards District Offices, airports, and can be found in your AIM, Appendix I. Copies of FAA form 5200-7 are available on the Internet at www.faa.gov/arp/topics.htm. From there, find "Bird Hazards" and you'll see "Bird Strike Report." Please take a

few minutes to help build an important database, even if you sustained no damage or injury. In many instances, the pilot provides the strike information to the tower personnel who then file the 5200-7 report with the FAA. The information is not used in a punitive way but is combined with all other reports to give a better picture of what is going on with wildlife in and around airports and the economic and safety impact these strikes have.

Remember, elephants can't fly, but an aircraft strike with a Canada goose can make you believe they do. ✈

QUICK FACTS

- Resident/non-migratory goose populations tripled from 1985-1995.
- Goose collisions with aircraft have doubled since 1990.
- Most strikes occur during the day.
- More than twice as many strikes occur during approach than during climb.
- Almost 20% of the strikes cause substantial damage; over half cause some type of damage.
- March and October are the worst months for strikes.
- Twenty five percent of strikes affect the flight negatively.
- The most expensive goose strike cost \$189 million.
- The deadliest goose strike took the lives of 24 Air Force crew.

**MIGRATORY CANADA GOOSE POPULATION
IN NORTH AMERICA, 1970-1995**

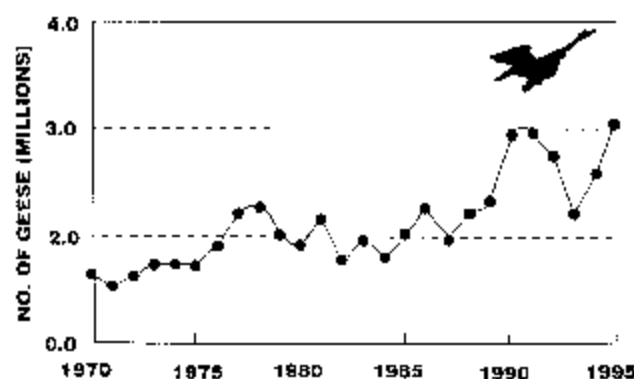


Figure 2



Data in the following tables are for all goose strikes reported to the FAA Wildlife Strike database. Most goose strike reports (66%) do not identify the species. Canada geese, snow geese, and brant represent 92%, 7% and 1% of the strikes that are identified to species.

State	No. of Reported Strikes	% of Strikes
IL	75	8.7
CT	43	8.3
CA	41	8.0
PA	37	7.2
NY	37	6.0
NJ	27	5.2
WA	24	4.7
OH	20	3.8
DC	19	3.7
MN	18	3.5

Table 1. Top 10 states for goose strikes, 1989-April 1997

Time of Day	No. of Reported Strikes	% of Strikes
Dawn	13	2.5
Day	224	43.6
Dusk	41	8.0
Night	168	32.6
Not reported	69	13.4
TOTAL	515	

Table 2. Number of aircraft collisions with geese by time of day, 1989 - April 1997

Year	No. of Reported Strikes	% of Reported Strikes
1989	41	8.2
1990	39	7.8
1991	46	9.2
1992	56	11.2
1993	76	15.2
1994	80	16.0
1995	85	17.0
1996	77	15.4
TOTAL	500	

Table 3. Number of aircraft collisions with geese per year, 1989-1996

Extent of Damage	No. of Incidents	% of Incidents
Destroyed	0	0
Substantial	95	18.4
Minor	135	26.2
Unknown damage	27	5.2
None	195	37.9
Unknown	63	12.2
TOTAL	515	

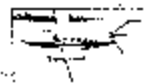
Table 4. Type of damage to aircraft, 1989 - April 1997

TIPS FOR AVOIDING BIRD STRIKES

- Avoid areas where there are concentrations of birds (marshes, lakes, rivers and protected wildlife areas).
- When approaching nontowered airports, fly over the airport to check for wildlife.
- Check NOTAM's for bird activity near airports and take appropriate precautions.
- Keep shatterproof goggles or glasses in the cockpit and use them when flying in or out of airports where birds congregate.
- When at low altitudes or approaching an area where bird encounters are likely, slow the aircraft as much as practical. The impact energy increases with the square of the velocity.
- If you encounter a flock of birds, try to stay above them as their first instinct is to dive.
- Some pilots believe your illuminated landing lights enable the birds to see you sooner.
- Use the windshield defroster in cold weather. A warm windscreen is less brittle and less apt to break on impact.
- Report birds to the tower or warn other pilots in the case of nontowered fields.

Author's Note: I would like to thank the following people for their assistance in providing support for this article: Ed Cleary, FAA, Office of Airport Safety and Standards; Satish Agrawal and Tom Hupf, FAA Technical Center; Richard Dolbeer, USDA/APHIS/WS; and Gene Wright, Ohio Department of Natural Resources.

Ms. Sandy Wright is employed by the U.S. Dept. of Agriculture, National Wildlife Research Center in Sandusky, Ohio. She manages the FAA Wildlife Strike Database which has had over 17,000 reported wildlife strikes to aircraft since 1989 and is growing by about 2,300 strikes per year.



APPENDIX 39

**Numbers, movements and behaviour of gulls using the Robin Hood Bay
Waste Disposal Site: Relationship to aircraft safety at the St. John's
Airport, Newfoundland**

**NUMBERS, MOVEMENTS AND BEHAVIOUR OF GULLS USING
THE ROBIN HOOD BAY WASTE DISPOSAL SITE: RELATIONSHIP TO AIRCRAFT
SAFETY AT THE ST. JOHN'S AIRPORT, NEWFOUNDLAND**

By

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For

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LGL Reports No. TA2131-2a and -3

30 September 1997

Preface

This volume contains two reports concerning bird hazards to aircraft safety at the St. John's Airport. The second report is the technical report for Phase 2 of a study of this issue conducted by LGL Limited for Transport Canada. The first report is an Executive Summary of both Phase 1 and Phase 2 of the study. The summary provides a concise overview of the project results and contains the main conclusions and recommendations of the study.

Davis, R.A. 1997. *Numbers, Movements and Behaviour of Gulls Using the Robin Hood Bay Waste Disposal Site: Relationship to Aircraft Safety at the St. John's Airport, Newfoundland. Executive Summary.* Report by LGL Limited, King City, Ontario, to Transport, Canada, Ottawa. 16 p.

Davis, R.A., I. Selnø and R. E. Harris. 1997. *Numbers, Movements and Behaviour of Gulls Using the Robin Hood Bay Waste Disposal Site and St. John's Airport, NF - 26 June to 6 October 1997.* Report by LGL Limited, King City, Ontario, to Transport Canada, Ottawa. 47 p.

**NUMBERS, MOVEMENTS AND BEHAVIOUR OF GULLS USING
THE ROBIN HOOD BAY WASTE DISPOSAL SITE: RELATIONSHIP TO AIRCRAFT
SAFETY AT THE ST. JOHN'S AIRPORT, NEWFOUNDLAND**

EXECUTIVE SUMMARY

By

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For

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EXECUTIVE SUMMARY

Introduction

Transport Canada identified a concern about the large numbers of gulls that occur on and near the St. John's Airport. These high numbers were thought to be a consequence of the presence of the Robin Hood Bay Landfill, about 4 km to the east of the airport. Substantial numbers of gulls were known to move between the landfill and Windsor Lake located WSW of the airport. Many of these gulls fly through aircraft approach/departure paths and some of these gulls occasionally land at the airport.

The presence of gulls on and near the airport creates potential bird hazards to the safety of aircraft using the airport. Collisions of jet and turbine aircraft with flocks of gulls can lead to serious aircraft accidents. To assess this concern, it is important to quantify the numbers of gulls involved and to determine the flightlines that are used by the gulls. To this end, Transport Canada commissioned LGL Limited to conduct two studies of the situation. The first was conducted from 16 November 1994 to 17 March 1995. The report of the Phase 1 study was

Davis, R. A. and B. Mactavish. 1995. *Gulls Associated with the St. John's Airport and the Robin Hood Bay Waste Disposal Site, Newfoundland*. Report by LGL Limited, King City, Ontario, to Transport Canada, Ottawa. 37p.

The second or Phase 2 study was conducted from late June through 5 October 1996.

Davis, R. A., J. Selno and R. E. Harris. 1997. *Numbers, Movements and Behaviour of Gulls Using the Robin Hood Bay Waste Disposal Site and St. John's Airport - 26 June to 6 October 1997*. Report by LGL Limited, King City, Ontario, to Transport Canada, Ottawa. 47 p.

To assist the reader in evaluating the significance of the bird hazards to aircraft in St. John's, this Executive Summary combines brief summaries of the main findings of both phases of the study. It then presents the overall conclusions and recommendations of the studies.

Background

Gull distribution and movements are determined by the locations of night roosting areas, feeding areas and loafing areas. During the breeding season, the locations of nesting colonies are also important. Gulls roost overnight communally in large aggregations in remote areas where they are safe from terrestrial predators. Roost locations are traditional and are used year after year. In the morning, gulls leave the roosts and travel to feeding and/or loafing areas. During the day, gulls spend their time feeding and loafing. Once feeding is completed, gulls spend long periods (often several hours) loafing and preening in relatively large open areas where they can see the approach of terrestrial predators. Loafing often occurs in areas directly adjacent to feeding areas but it can also occur in suitable locations, such as airports, that are several km distant from the main feeding areas. Figure 1 illustrates the locations of important features in the St. John's region.

In addition to using traditional feeding, loafing and roosting areas, gulls also use traditional flight paths among the areas. These paths are usually the shortest routes, but there may be diversions to include en route washing or loafing areas. Gulls have been known to travel over 60 km between night roosts and major feeding areas (e.g. landfills) in some circumstances. Thus, any study of gull movements around an airport must include a large study area to insure that all of the major determinants of gull movements in the area are known and understood.

Numbers of Gulls

Large numbers of gulls frequented the Robin Hood Bay Landfill during the winter. The species involved (Herring Gull, Great Black-backed Gull and Glaucous Gull) are all big birds that could damage an aircraft, if they were struck. The gulls that fed at the landfill loafed on the ice of nearby Quidi Vidi Lake. The overall numbers involved approached 25,000 gulls (Figure 2). There was a steady movement of gulls between the landfill and the lake throughout the day. Thus, it was necessary to combine the counts from both areas to determine the overall numbers involved.

Comparisons with data from other parts of the Avalon Peninsula indicate that the numbers of gulls wintering in the St. John's area is greatly inflated by the presence of the Robin Hood Bay Landfill. If the landfill were not present, or if it supported fewer gulls, then the numbers of gulls in the St. John's area would undoubtedly decline.

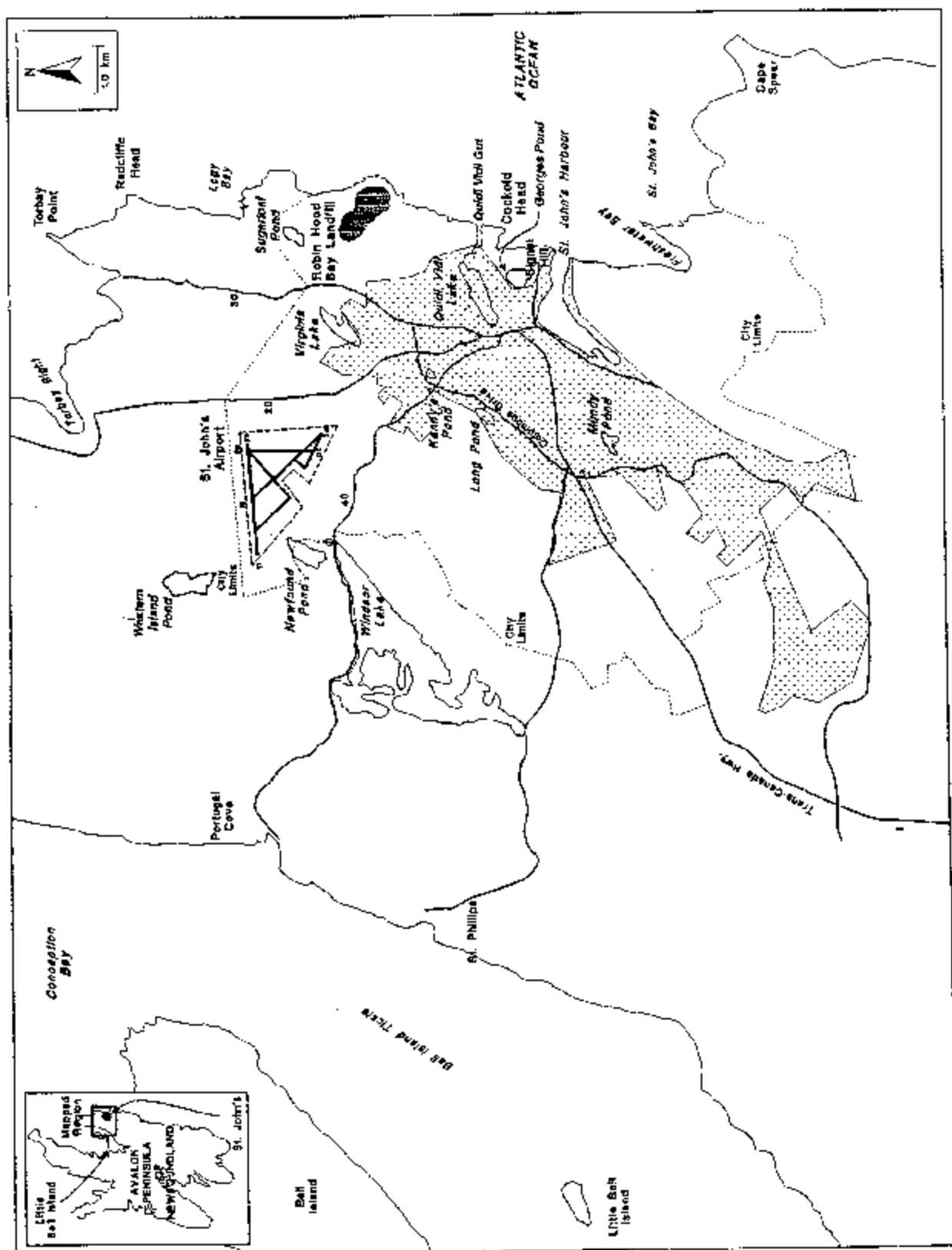


Figure 1. Principal features affecting gull distribution in the St. John's, NF area.

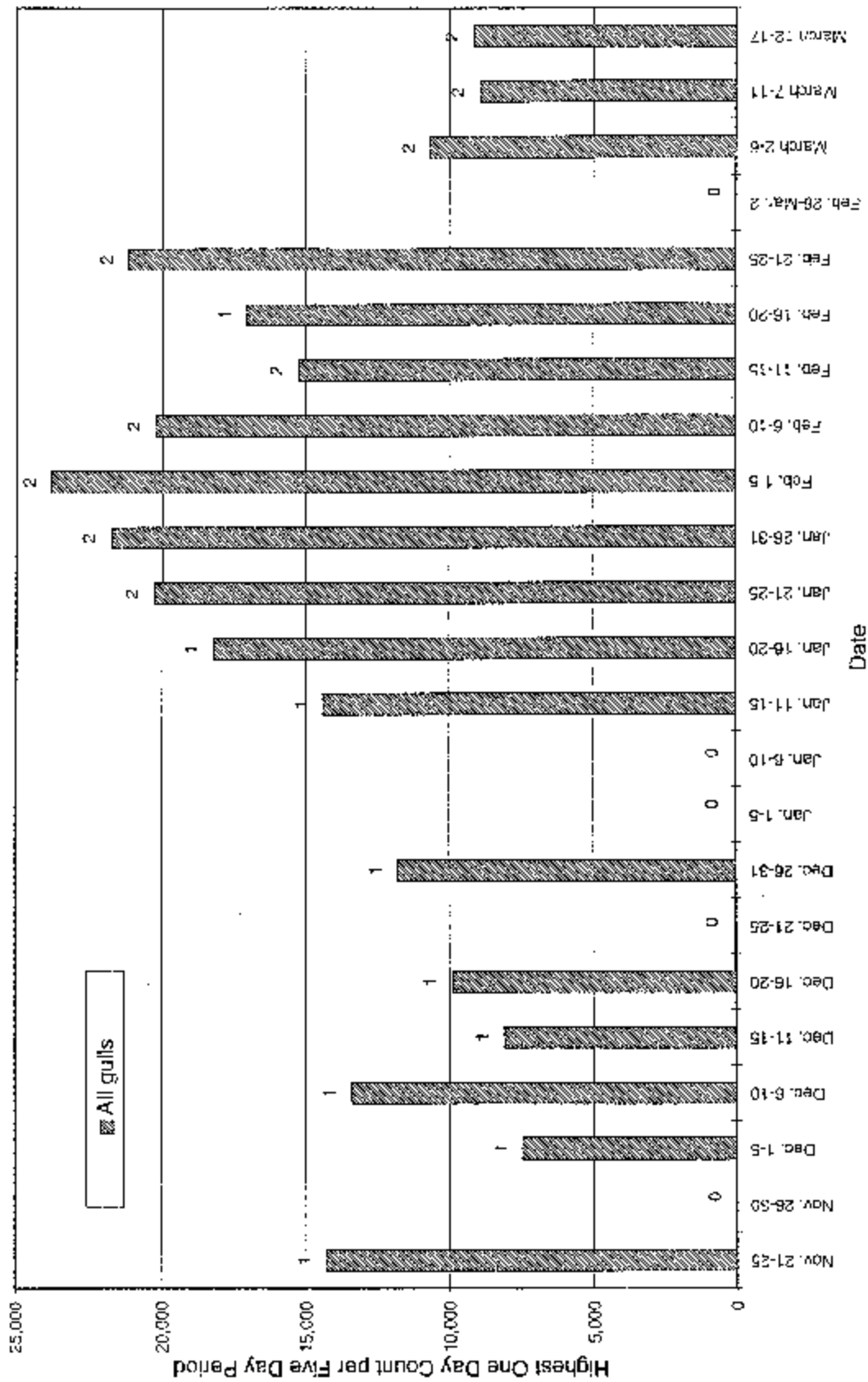


Figure 2. Highest one day count of all gulls per five day period at Quidi Vidi Lake and Robin Hood Bay Landfill, combined --- 21 November 1994 to 17 March 1995. Numbers at the top of each column indicate the number of censuses in that five day period.

The numbers of gulls present at the landfill during the summer and early fall study were more variable. During this period, few gulls loafed on Quidi Vidi Lake and it was not necessary to include counts from the lake when determining the numbers of gulls frequenting the landfill. Figure 3 summarizes the numbers of gulls present at the landfill during the summer and early fall.

About 7,500 gulls were present at the landfill in late June with about 95% being Herring Gulls and 5% Great Black-backed Gulls. The numbers present were fairly steady through July ranging from about 4,000 to 8,500 gulls. Clearly, more gulls actually used the landfill as there was significant gull traffic throughout the day between the landfill and the nearby nesting colonies on coastal cliffs to the north and south of the landfill. Again, most of the gulls present were herring gulls.

There was a significant decline in the numbers of gulls present at the landfill in late July and the first half of August (Figure 3). Non-weekend numbers ranged from about 400 to 1,500 birds. The decline coincided with the fledging of young gulls from the nearby colonies. Banding results from the late 1960's and early 1970's indicate that young-of-the-year and yearling Herring Gulls move north from the nesting colonies in August, perhaps following capelin which spawn in August in northern Newfoundland and Labrador (Threlfall 1978, Bird-banding 49:116-124). The adult gulls may also move north after the young have left the colony. These movements may explain the observed decline in gull numbers at the landfill and at other day-use sites in late July and early August 1996.

There was a major influx of gulls into the landfill in the last half of August. About 12,500 gulls were present on 13 August. Numbers rose steadily to 30,140 by 23 August. Numbers of gulls at the landfill continued to range between 20,000 and 29,000 from late August through mid September. The numbers declined slightly to 16,000-18,000 in late September and early October (Figure 3). During the mid August to early October period, the numbers of herring gulls at the landfill ranged between 12,000 and 26,000 while the numbers of great black-backed gulls ranged between 2,300 and 6,100.

Gull Flight Paths

In situations where gulls feed at the Robin Hood Bay Landfill and fly east to the nearby ocean to spend the night, they do not create hazards to aircraft safety at the airport. Concerns arise when regular gull flight paths occur inland in the vicinity of the airport and/or aircraft

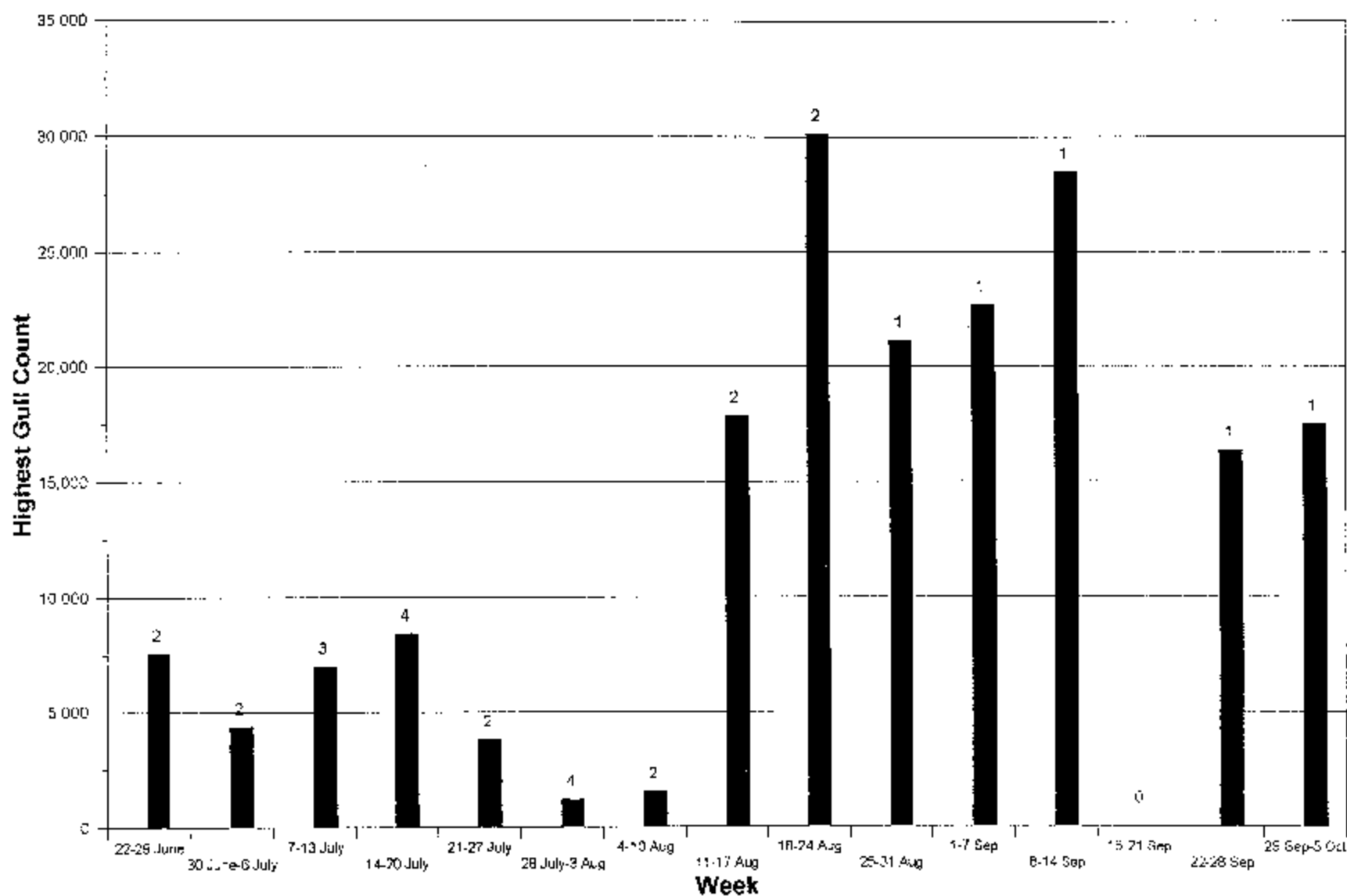


Figure 3. Highest one day count of gulls per week at the Robin Hood Bay Landfill -- 22 June to 5 October 1996. Numbers at top of each column indicate the number of censuses in that seven day period.

approach/departure routes. The size and locations of gull flight paths vary with season in the St. John's area.

Late Fall - Figure 4

Of concern to the airport, is the fact that in late fall and winter, substantial numbers of gulls roost at night at Little Bell Island in Conception Bay to the west of the Airport. These birds often stop at Windsor Lake, and probably Newfound Pond, during flights between the landfill and Little Bell Island. Thus, these gull flights pass very close to the south end of Runways 16/34 and 20/02 at the St. John's Airport. Nonetheless, the majority of the gulls that feed at the landfill roosts on the cliffs and ocean to the east of the landfill. A few thousand individuals are involved in the flights to Little Bell Island.

Winter - Figure 5

During mid winter when the lakes are frozen, the gulls do not stop at Windsor Lake, and most gulls follow a more southerly route between the night roost and the day-use areas, primarily Quidi Vidi Lake. These more southerly flights are not hazards to aircraft safety because they mostly occur below the altitudes of aircraft on approach to Runways 02 and 34. Again, the majority of the gulls roost to the north and south along the coastal cliffs to the north and south of the landfill and on the ocean to the east.

Gull Nesting Season - Figure 6

The major gull nesting colonies in the St. John's area occur south of the landfill along the coastal cliffs on the eastern side of Small Point, Cuckold Head and St. John's Bay and north of the landfill on the cliffs of Logy Bay, Redcliff Head and Torbay Point (see Figure 1). Birds from the north generally arrive and depart the landfill from the NNW via Sugarloaf Pond. The main access to and from the southern colonies is via the southeast corner of the landfill over Bobbies Cove (Figure 6). During the nesting season, gulls do not remain at the landfill for the day, but rather move back and forth between the landfill and their nesting colonies. For example, during a watch from 05:15 to 08:00 on 26 June 1996, a total of 3,202 gulls arrived at the landfill through Bobbies Cove, while 2,085 gulls left the landfill, presumably to return to their young at nests in the colonies to the south.

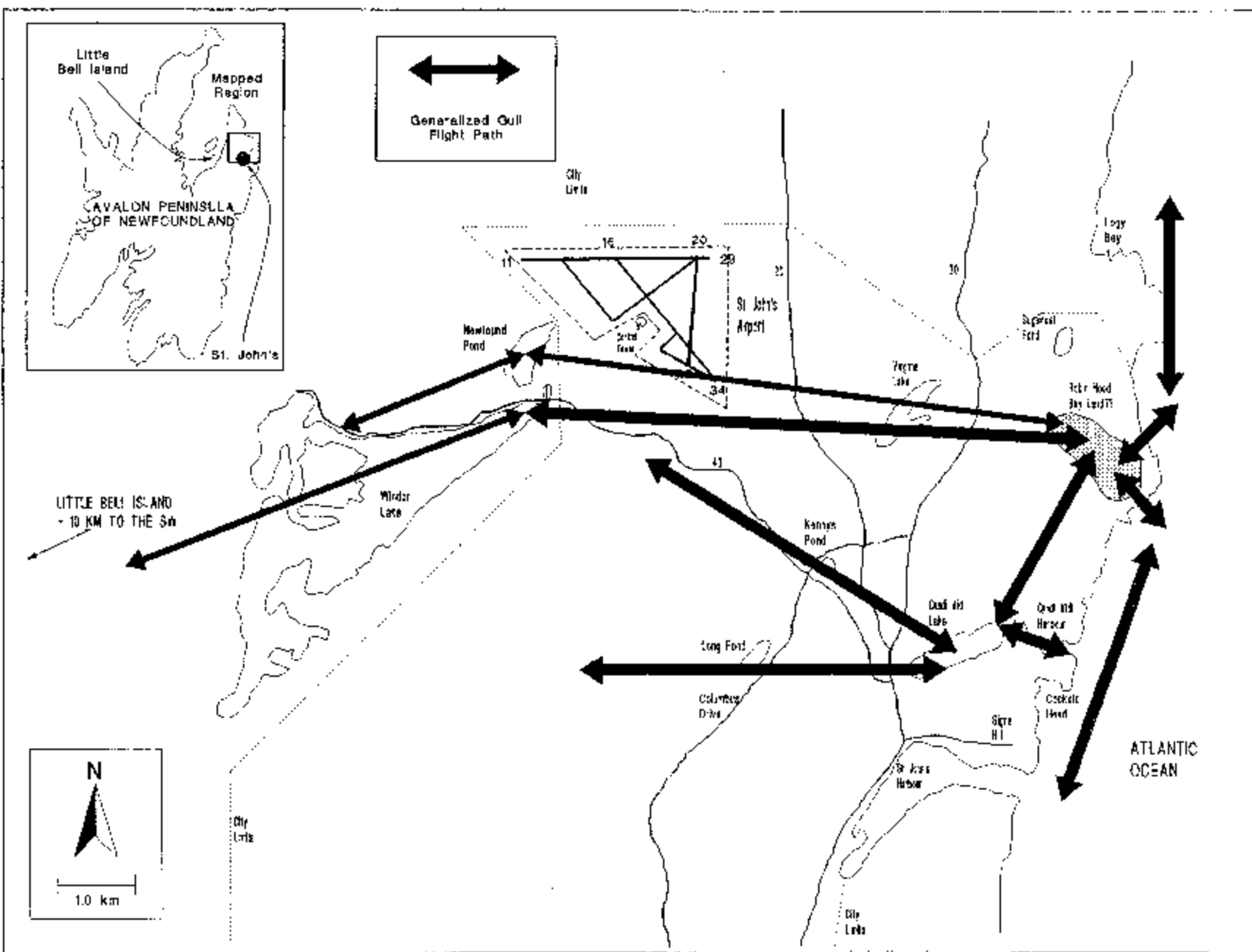


Figure 4. Stylized representation of the principal gull flight paths in the St. John's region in late fall.

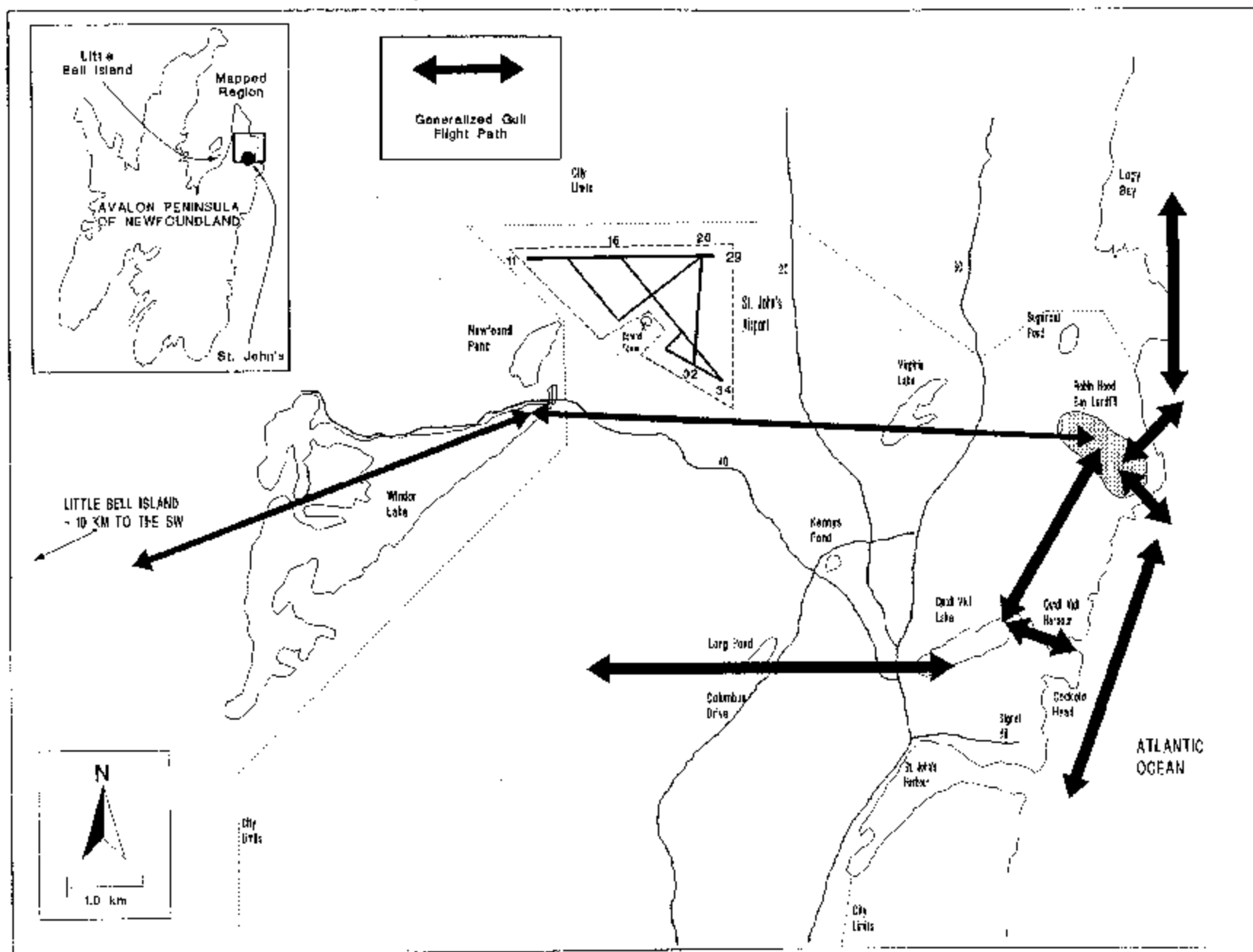


Figure 5. Stylized representation of the principal gull flight paths in the St. John's region in winter.

During the nesting season, there were only small numbers of gulls at inland locations. The flight line between Little Bell Island and the landfill was not being used. Only small numbers of gulls used Virginia Lake (average of 4 gulls on 7 surveys from 26 June to 23 July) and Windsor Lake (average of 36 gulls on 11 surveys from 25 June to 23 July) during the nesting season. Thus, gull flight paths create minimal hazards to aircraft safety during the gull nesting season.

Late Summer/Early Fall - Figure 7

When the gulls returned to the St. John's area in mid August, they established major inland movement patterns that were maintained until the study terminated in early October. Twice daily flights between the night roost at Little Bell Island and the Robin Hood Bay Landfill were re-established. In addition, there were movements between the landfill and loafing areas on Windsor Lake, Newfound Pond, and Virginia Lake. Many of the gulls flying to Windsor Lake and Newfound Pond stopped at Virginia Lake on the way. These flight lines are illustrated on Figure 7.

These east-west flights contained substantial numbers of gulls. For example, nearly continuous observations at the west end of the landfill from 06:40 to 17:45 on 30 September revealed an estimated 11,081 gulls arriving from the direction of Virginia Lake to the west and 4,549 gulls returning in that direction. Heavy rain terminated these observations. Observations were made from the parking lot at the passenger terminal on the south side of the airport from 06:00 to 19:50 on 11 September. An estimated 6,885 gulls flew east and 9,053 flew west. Similar observations were made from 06:30 to 17:30 on 26 September and 17:30 to 18:50 on 27 September. The combined one day totals for these dates were 4,379 gulls flying to the east and 7,647 passing to the west. Thus, over 16,000 and 12,000 gulls passed through the Approach Paths to Runways 02 and 34 on the two days that were sampled.

The actual flight paths followed on these east-west flights depended partly upon the wind direction. On 11 September, a 20 km/h south wind pushed the gulls north so that they were passing just south of the terminal parking lot and close to the south ends of Runways 16/34 and 20/2. On 27 September, a strong north wind caused the gull flightline to be 1 to 1.5 km south of the airport. Depending upon cloud cover, time of day, temperature and wind, the gulls could be anywhere from a few m above ground to several hundred m agl.

On 26 September, light aircraft from the flying school made repeated take-offs into the south wind and through flocks of passing gulls. On at least one occasion, a gull was observed taking

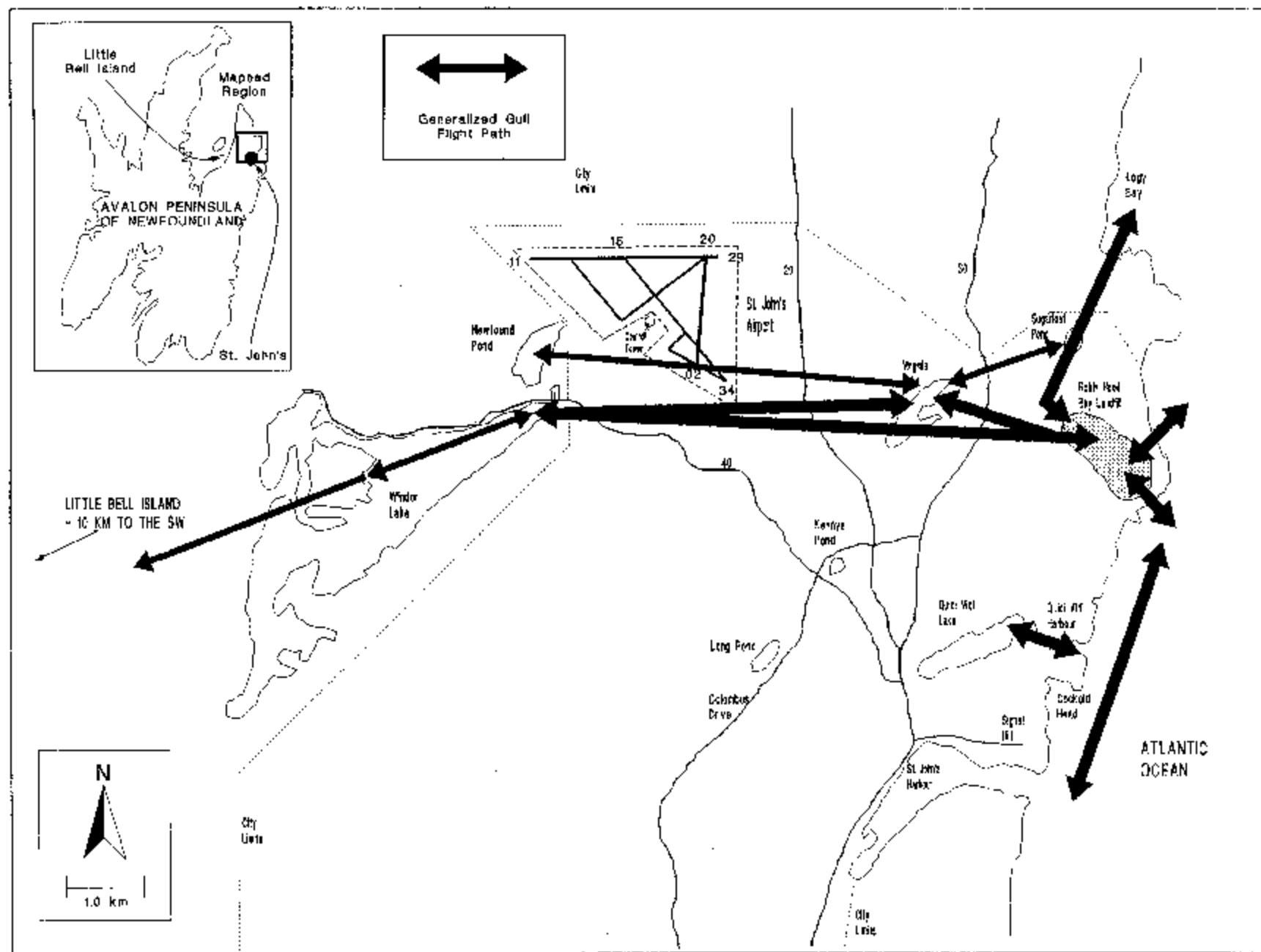


Figure 7. Stylized representation of the principal gull flight paths in the St. John's region in late summer and early fall.

sudden avoidance actions to avoid the aircraft. Of greater concern is the situation when there is low cloud and a turbojet aircraft on final approach lets down through the cloud and encounters a flock of gulls that did not see the approaching aircraft. A significant hazard would be created.

Gulls at the Airport

Airport personnel note that gulls are most numerous on the airport during the spring, summer and early fall. The data from the ground personnel indicate that the highest numbers of gulls are present on the airport in late May/June and September/October. Not surprisingly, gulls were not frequent on the airport during the Phase I study in late fall and winter when the inland lakes were frozen.

Gulls were present in small numbers at the airport on several days in August through early October. The most persistent visitors were a small number (10-20) of Ring-billed Gulls. These were mostly young-of-the-year and subadult birds. These birds were difficult to disperse off the airport. It is of interest to note that the presence of these gulls is undoubtedly independent of the presence of the Robin Hood Bay Landfill. This conclusion is based on the fact that Ring-billed Gulls were not observed at the landfill in either of the two studies that were conducted. However, Ring-billed Gulls were regularly observed in St. John's Harbour and in Quidi Vidi Lake and these areas are the likely sources of the birds at the airport.

Herring and Great Black-backed Gulls also occurred at the airport, sometimes necessitating control action by airport staff. Propane cannons, pyrotechnics, and live ammunition were used. Dead gulls were left on the ground to frighten other gulls and to indicate danger to them. There is an important question about the best strategy for handling gulls that land at the airport. It is not clear that the best method is presently being used.

Conclusions

It is clear that the Robin Hood Bay Landfill attracts up to thirty thousand large gulls. The presence of the landfill has significantly increased the population of gulls that can be supported by the St. John's area. In some respects the landfill is well located in relation to the airport. That is, it is between the airport and the ocean and it is closer to the ocean. The situation would be much worse if the landfill were located to the west of the airport. Notwithstanding the above, the landfill creates several serious bird hazards to the safety of aircraft using the St. John's Airport.

Gull Flight Paths

In June and July, gulls are nesting and there are few inland movements. There is intensive use of the landfill by gulls that travel to and from nesting colonies on coastal cliffs to the north, south and east of the landfill. These flights do not create hazards to aircraft. At the end of July and in early August most gulls leave the St. John's area, or at least the landfill, to pursue capelin and other natural food.

There was a major influx of gulls into the area in the last half of August and a peak of 30,000 gulls was reached at the landfill. During the mid August through November period, significant hazards to aircraft safety are created by regular gull flights between the landfill/Virginia Lake and Windsor Lake/Newfound Pond. Some of these birds are en route to the night roost at Little Bell Island in Conception Bay and some of them are merely loafing at Windsor Lake and Newfound Pond before returning to the landfill. When quantified on two days, these movements involved 16,000 and 12,000 gull passages per day through aircraft approach paths to Runways 02 and 34. These movements occur from mid August through to freeze-up of Windsor Lake, a period of approximately 105 days. If the gull passages averaged 14,000 per day during this period, then there would be nearly 1,500,000 gull passages through the aircraft approach/departure paths during every late summer/fall period. The degree of hazard on any given day will be a function of the wind direction, cloud ceiling, aircraft traffic, etc.

An additional hazard occurs when gulls tower over Virginia Lake. Large groups can reach altitudes of several hundred metres before drifting back toward the landfill or off to the west toward Windsor Lake. The latter birds would be high enough to interact with aircraft on take-off from Runway 16. Also, gulls tower high over the landfill on occasion and then drift away from the landfill. Some aircraft pass close to the landfill when they approach from the south and then angle in to land on Runway 11. Interactions are possible in these situations.

In winter, most gulls move to the Little Bell Island roost by way of Quidi Vidi Lake; thus, they fly south of, and below, the aircraft approach/departure paths. Relatively small numbers of gulls follow the more hazardous direct route from the landfill to Little Bell Island.

The situation in spring is not clear because there have been no studies in the April/May and early June period. It is possible that significant flights occur between the landfill and Windsor Lake and Newfound Pond, after they become free of ice.

The hazards associated with gull flight paths mostly occur off airport property and involve flying gulls that would be difficult to control. These birds are beyond the reach of airport bird control efforts. The most effective way of mitigating this problem is to prevent the gulls from using the Robin Hood Bay Landfill.

Gulls at the Airport

Based on airport records, the key period for gull use of the airport is the late May and June period when no studies have been done. Many of the gulls that fly over or land at the airport undoubtedly originate at the landfill. However, the persistent ring-billed gulls that visited the landfill in late summer were not associated with the landfill.

In the long term, if gulls are prevented from using the landfill, then fewer gulls will frequent the airport. However, bird control at the airport will still be necessary to deal with those gulls that are not associated with landfills. In addition, the airport bird control plan would have to be upgraded to deal with gulls that might be diverted to the airport in the initial stages of gull control at the Robin Hood Bay Landfill.

Recommendations

Clearly, there are significant bird hazards to the safety of aircraft using the St. John's Airport. The solution for solving this serious problem is conceptually simple but operationally difficult. There are two components to the solution.

1. Establish a gull control program at the Robin Hood Bay Landfill to prevent its use by significant numbers of gulls.
2. Continue an upgraded bird control program at the St. John's Airport.

The control program at the landfill will cause gulls to stop coming to the landfill. It will lead to an eventual decline in the numbers of gulls in the St. John's area. If the landfill is not accessible to gulls, then gulls from the Little Bell Island night roost will stop flying to the landfill. Similarly, there will be no gulls to fly from the landfill to Windsor Lake. Therefore, control of the gulls at the Robin Hood Bay Landfill will terminate the gull flight paths that presently create the above-noted bird hazards to aircraft safety.

The initiation of control at the landfill will cause short-term confusion as gulls attempt to find alternate sources of food. During this period, the bird control program at the airport needs to be extra vigilant and should probably be supplemented for several months. In general, the objectives of the airport control efforts probably need to be clarified.

The difficulty of instituting a successful gull control program at the Robin Hood Bay Landfill should not be underestimated. It has a history of use by tens of thousands of gulls, it is close to the ocean where nesting sites and loafing habitat are inaccessible to bird controllers, and the landfill does not use either daily or interim cover. Thus, edible waste remains exposed for long periods and there are large areas of good gull loafing habitat. In addition to the technical problems, there is a financial constraint in St. John's that may affect the success of the program.

It is very important that any control program implemented at the Robin Hood Bay facility should be done so only under the direction of an experienced bird control biologist. This will be less expensive in the long run since the learning period will be shorter. Also, more importantly, the initiation of the program is less likely to create unintended hazards to aircraft safety.

**NUMBERS, MOVEMENTS AND BEHAVIOUR OF GULLS USING
THE ROBIN HOOD BAY WASTE DISPOSAL SITE AND ST. JOHN'S AIRPORT, NF
- 26 JUNE TO 6 OCTOBER 1996**

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LGL Report No. TA2131-3

30 September 1997

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INTRODUCTION

Transport Canada identified a concern about the large numbers of gulls that occur on and near the St. John's Airport. These high numbers were thought to be a consequence of the presence of the Robin Hood Bay Landfill, about 4 km to the east of the airport. Substantial numbers of gulls are known to move between the landfill and Windsor Lake located WSW of the airport. Many of these gulls fly through aircraft approach/departure paths and some of these gulls occasionally land at the airport.

The presence of gulls on and near the airport creates potential bird hazards to the safety of aircraft using the airport. Collisions of jet and turbine aircraft with flocks of gulls can lead to serious aircraft accidents. To assess this concern, it is important to quantify the numbers of gulls involved and to determine the flightlines that are used by the gulls. To this end, Transport Canada commissioned LGL Limited to conduct two studies of the situation. The first was conducted from 16 November 1994 to 17 March 1995. The report of the Phase 1 study was

Davis, R. A. and B. Mactavish. 1995. *Gulls Associated with the St. John's Airport and the Robin Hood Bay Waste Disposal Site, Newfoundland*. Report by LGL Limited, King City, Ontario, to Transport Canada, Ottawa. 37p.

The second or Phase 2 study was conducted from late June through 5 October 1996. It is the subject of the present report.

STUDY AREA AND METHODS

Gull distribution and movements are determined by the locations of night roosting areas, feeding areas and loafing areas. During the breeding season, the locations of nesting colonies are also important. Gulls roost communally at night in large aggregations in remote areas where they are safe from terrestrial predators. Roost locations are traditional and are used year after year. In the early morning, gulls leave the night roosts and travel to feeding and/or loafing areas. During the day, gulls spend their time feeding and loafing. Once feeding is completed, gulls spend long periods (often several hours) loafing and preening in relatively large open areas where they can see the approach of terrestrial predators. Loafing often occurs in areas directly adjacent to feeding areas but it can also occur in suitable locations, such as airports, that are several km distant from the main

feeding areas. During the nesting season, gulls return to the nest after feeding and spend minimal amounts of time at loafing areas.

In addition to using traditional feeding, loafing and roosting areas, gulls also use traditional flight paths among the areas. These paths are usually the shortest routes, but there may be diversions to include en route washing or loafing areas. Gulls have been known to travel over 60 km between night roosts and major feeding areas (e.g. landfills), in some circumstances. Thus, any study of gull movements around an airport must include a large study area to insure that all of the major determinants of gull movements in the area are known and understood.

The locations of the major sites surveyed during the present study are shown on Figure 1. In addition to the St. John's (Torbay) Airport itself, the major areas for gulls that were surveyed were the Robin Hood Bay Landfill (feeding and loafing), Quidi Vidi Lake (loafing), Windsor Lake (loafing and roosting), Newfound Pond (loafing), Kenny's Pond (loafing), Sugarloaf Pond (loafing), and Virginia Lake (loafing). Other potentially important areas were surveyed for the following reasons. Little Bell Island in Conception Bay was used as a night roost by gulls from the Robin Hood Bay Landfill. The coast between Torbay Point and Quidi Vidi Gut contains cliffs that were used by nesting, roosting and loafing gulls. St. John's Harbour was a feeding area and a loafing area.

In addition to the surveys at specific sites, observations were also made of the gull flight lines among the various sites. Specific emphasis was placed on major flight lines that could affect the airport. These involved observations at and near the airport itself, the Robin Hood Bay Landfill, Virginia Lake, Windsor Lake and Little Bell Island.

The study was conducted from 26 June to 6 October 1997, although occasional observations were made later. The majority of the field work was conducted by the second author. Observational techniques using binoculars and a spotting scope were employed. The specifics of each observation type are discussed under each survey type, as appropriate.

ROBIN HOOD BAY LANDFILL

Gulls spend the day feeding and loafing. These behaviours sometimes occur at the same site and sometimes at different sites. Both activities occur at the Robin Hood Bay Landfill. This landfill site is the main, non-marine source of food for gulls in the St. John's area during summer and fall.

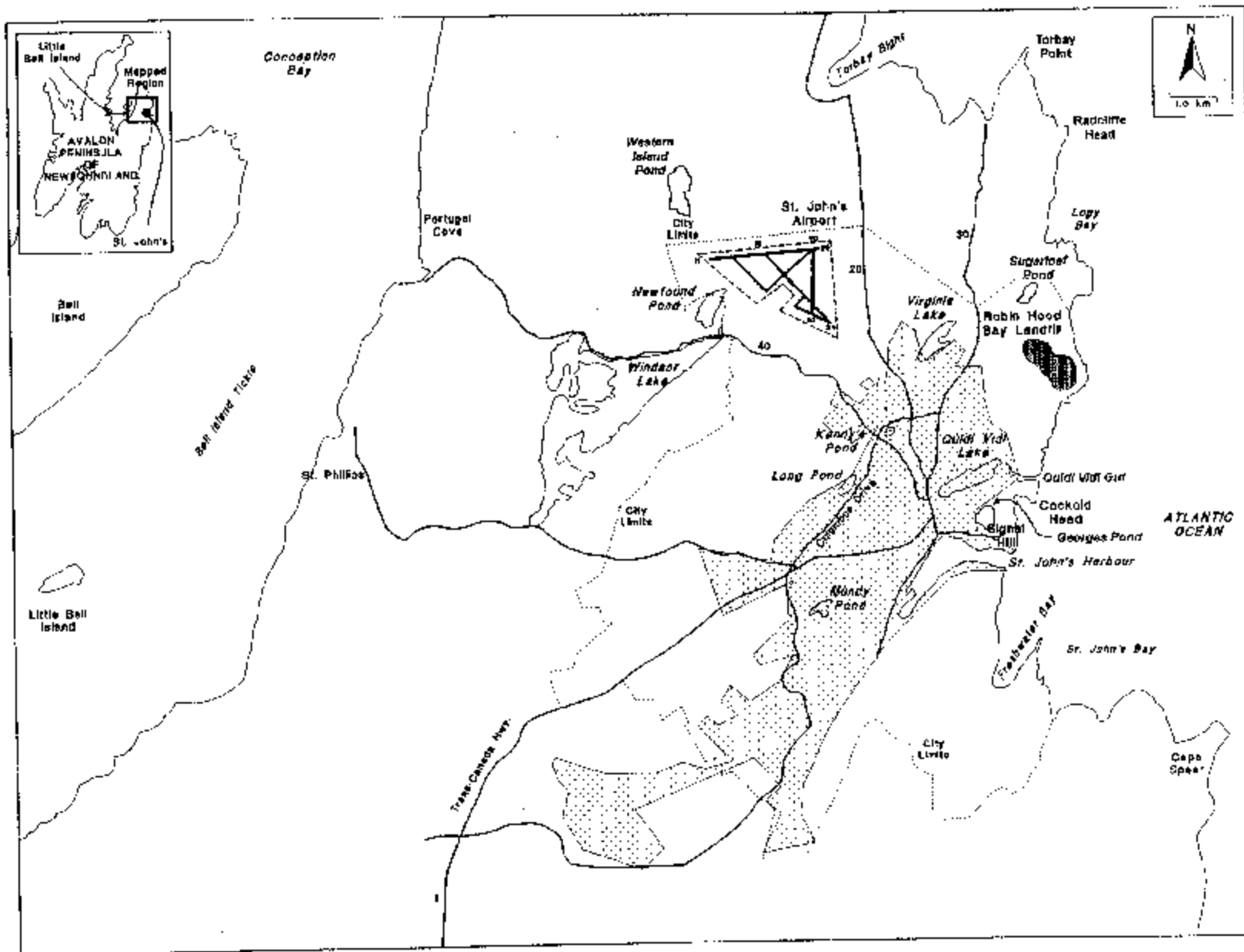


Figure 1. Principal features affecting gull distribution in the St. John's, NF area.

The landfill property is about 204 ha (510 acres) out of which about 60 ha (150 acres) have been or are being used for waste disposal. The landfill accepts about 135,000 tonnes of waste per year. At this rate, the landfill can operate for another 25 to 40 years. The tipping fee in 1996 was a very modest \$12.00 per tonne. No daily or interim cover is applied to the waste so food is available to the gulls for prolonged periods. In addition to the food source, the landfill has large open, flat areas that provide prime gull loafing habitat. Also present are puddles, streams and small ponds that are used for bathing and drinking.

Numbers of Gulls

Counts of gulls at the landfill were conducted between 08:30 and 12:00. This timing was chosen because most gulls had arrived at the landfill by this time and few had left for the day. This pattern of gull use of the landfill was different during the nesting season (discussed later). During the count period, the gulls were actively feeding and many were loafing.

The counts were made from the outer "ring road" of the landfill; the gulls could be observed below on the flats through a spotting scope or binoculars. Closer observations were also made from a car on the lower roads through the landfill. Because of the large area and the large numbers of gulls that were often present, the gull counts were very time-consuming. For this reason, the species composition and the age classes of the various species were determined only on 17 selected surveys. Total numbers of gulls present were determined on 28 surveys.

An additional problem in counting the gulls was that several times each day many of the loafing and feeding gulls would suddenly be scared into the air where they would circle by the hundreds or thousands over the landfill. These sudden flushings were often precipitated by a raptor, such as a Bald Eagle. An extreme example occurred at 14:30 on 23 August when about 10,000 gulls flushed and towered over the landfill. These types of events often complicated the gull counts.

The numbers and species of gulls recorded at the Robin Hood Bay Landfill during this study are presented in Table 1 and Figure 2. The numbers ranged from a low of 410 gulls on 31 July to a high of 30,140 on 23 August. During the period from the start of the study in late June to mid July, the numbers of gulls at the landfill during a survey ranged from about 4,000 to 8,500 birds. Many of these birds were nesting adults that were feeding young at nests along the coastal cliffs to the north and south of the landfill. These birds arrived at the landfill, obtained food, and returned to their nests. They might make several visits to the landfill during the day. Thus, the numbers

Table 1. Numbers and species of gulls recorded at the Robin Hood Bay Landfill (26 June-3 October 1996).

Date	Herring Gull	Great Black-backed Gull	Glaucous Gull	Iceland Gull	Lesser Black-backed Gull	Totals
June 26	-*	-	-	-	-	7,400
27	7,174	383	1	0	0	7,558
July 3	-	-	-	-	-	3,907
4	2,972	1,371	1	0	0	4,344
9	-	-	-	-	-	5,735
11	6,317	662	1	0	0	6,980
12	-	-	-	-	-	5,740
15	-	-	-	-	-	8,410
16	-	-	-	-	-	6,127
18	-	-	-	-	-	4,250
19	3,708	435	1	0	0	4,144
23	-	-	-	-	-	3,786
28	-	-	-	-	-	350
29	736	102	2	0	0	840
30	986	164	3	1	0	1,154
31	337	71	2	0	0	410
Aug 1	357	87	2	1	0	447
5	1,376	131	3	0	0	1,509
6	872	90	3	0	0	965
15	-	-	-	-	-	12,435
16	14,253	3,576	1	0	0	17,830
21	19,059	3,031	0	0	0	22,090
23	26,217	3,923	0	0	0	30,140
28	17,049	3,083	1	0	0	20,133
Sep 4	16,565	6,116	1	0	0	22,682
12	-	-	-	-	-	28,480
23	13,967	2,360	0	0	2	16,329
Oct 3	14,108	3,342	0	0	0	17,450

* - indicates that species composition was not determined on this survey.

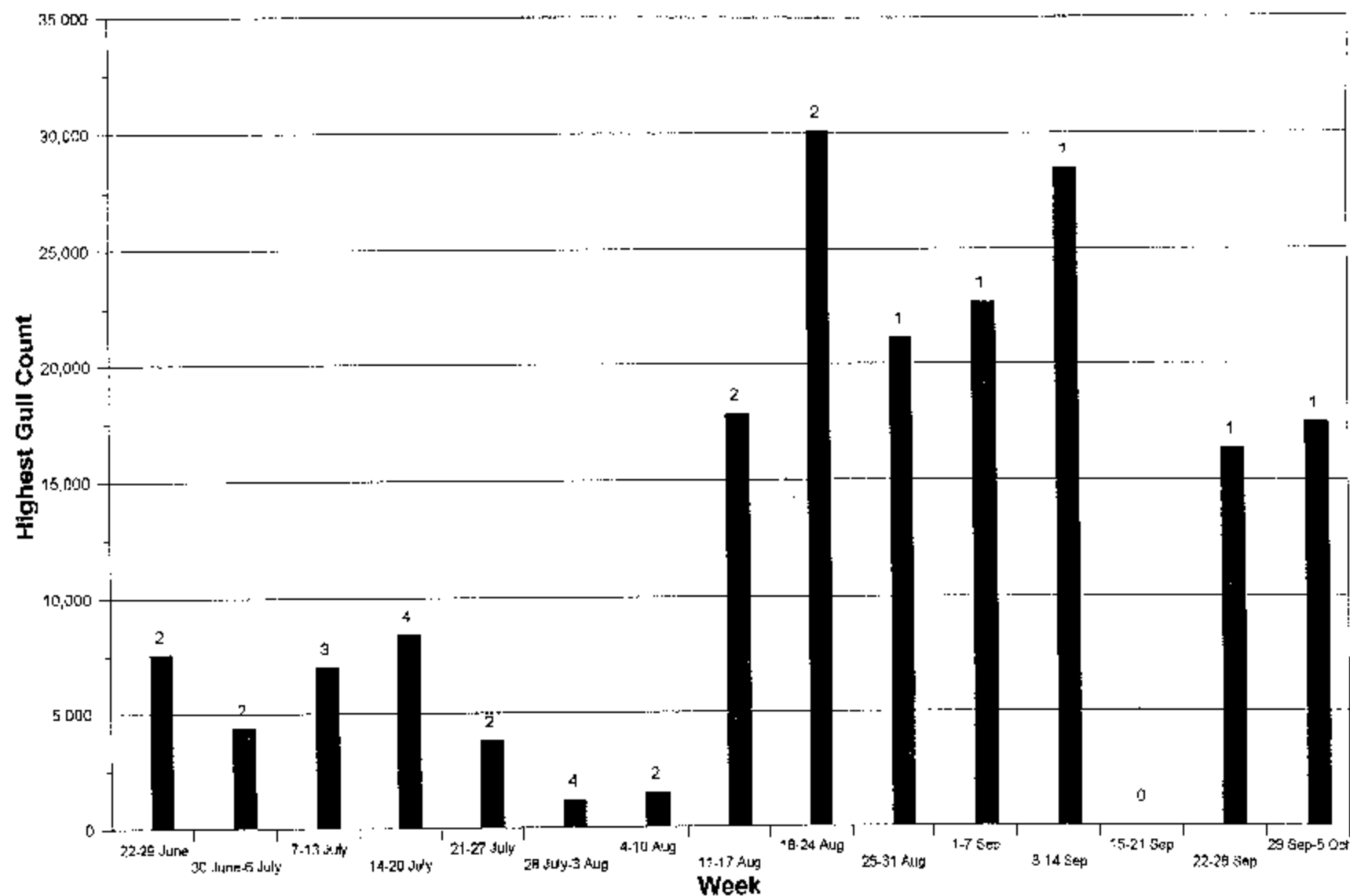


Figure 2. Highest one day count of gulls per week at the Robin Hood Bay Landfill -- 22 June to 5 October 1996. Numbers at top of each column indicate the number of censuses in that seven day period.

recorded at the landfill during any survey represent only a fraction of the numbers of gulls that visit the landfill during the course of the day. When nesting is completed in late July, gulls that visit the landfill tend to spend a significant portion of the day at the landfill and associated loafing areas.

There was a marked decrease in the numbers of gulls using the landfill in mid-summer (last week of July and first two weeks of August). Only a few hundred gulls were present during this period (Table 1). It is thought that the gulls fed on marine food during this period, perhaps on late spawning capelin stocks in northern Newfoundland and southern Labrador. Large numbers of gulls returned from the sea in mid August with numbers increasing from 12,435 on 15 August to 30,140 on 23 August. The numbers ranged from about 17,000 to 28,000 for the period from late August to early October (Table 1).

Gull Species Composition

The overwhelming majority of the gulls using the Robin Hood Bay Landfill during the study were Herring Gulls and Great Black-backed Gulls (Table 1). Very small numbers (3 or less) of Glaucous Gulls, Iceland Gulls, and Lesser Black-backed Gulls were noted. Glaucous Gulls are relatively common at the landfill during winter but the latter two species are never common there. It is of interest to note that the Ring-billed Gull was never seen at the landfill, even though it commonly frequents landfills throughout much of North America.

The species composition at the landfill was similar during the nesting (27 June to 19 July) and late summer/early fall (16 August to 3 October) periods. During nesting, Herring Gulls comprised 88% (average of 5,043) and Great Black-backed Gulls 12% (713) of the gulls present. In the late summer/early fall, Herring Gulls comprised 83% (average of 17,317) and Great Black-backed Gulls 17% (3,633) of the gulls present.

Age Composition of Gulls

The ages of gulls can be differentiated on the basis of plumage for the first few years of life. Age data for the two common species were collected at the Robin Hood Bay Landfill on 17 dates spread throughout the study period.

Overall, 97.9% of the Herring Gulls recorded at the landfill were adult birds (3 yr +). This pattern was fairly consistent throughout the study period with the percentage of adults per survey

ranging from 90.8 to 99.2% (Table 2). The first young-of-the-year (YOY) Herring Gulls appeared at the landfill 29 July when 4 were present. The numbers increased gradually through the fall. Influxes of YOY Herring Gulls occurred on 23 August (375) and 3 October (635) (Table 2).

The age composition pattern for Great Black-backed Gulls was somewhat different (Table 3). Overall, 85.7% of the Great Black-backs identified at the landfill were adult birds (3 yr +). However, during the nesting season and immediate post-nesting period, there were significant numbers of non-breeding, subadult Great Black-backed Gulls present. This was particularly true in early July when up to 709 1st-yr (yearlings) and 228 2nd-yr birds were present on the 4th. After mid July, the numbers of 1st and 2nd year birds declined and remained low for the rest of the study period (Table 3). The first young-of-the-year (YOY) Great Black-backed Gulls appeared at the landfill on 5 August. Numbers increased until mid August. Through the remaining part of the study, numbers of YOY Great Black-backs numbered upwards of 350 birds (Table 3).

Gull Use of Landfill

Gulls used the Robin Hood Bay Landfill for feeding and loafing. The major sub-areas of the landfill are depicted in Figure 3. The landfill had two active waste disposal areas that supported the feeding gulls. As at most landfills used by gulls, far more gulls were loafing than feeding at any one time. Large numbers of gulls loafed on the flat ground and recently compacted garbage beside the active disposal areas (areas A, D on Figure 3). Other major loafing areas were Areas B and C (Figure 3).

The gulls appeared not to loaf in areas with old exposed garbage; instead they preferred the areas where soil had been compacted on top of the garbage creating large flat surfaces. The large Great Black-backed Gulls also loafed in grassy areas; their large size allowed them to see over the grass. Small numbers of gulls used many parts of the site, but on all counts the gulls were mainly found in Areas A,B,C and D close to the active disposal areas.

Other Species

The five species of gulls that frequented the Robin Hood Bay Landfill during this study are enumerated in Table 1. Summarized here is additional information about these and several other potentially hazardous species of birds that were found at the landfill.

Table 2. Age composition of Herring Gulls recorded at the Robin Hood Bay Landfill (27 June-3 October 1996).

Date	Young-of-year		1st year		2nd year		3 years+		Totals
	N	%	N	%	N	%	N	%	
June 27	0	0.0	47	0.7	98	1.4	7,029	98.0	7,174
July 4	0	0.0	46	1.5	64	2.2	2,862	96.3	2,972
11	0	0.0	68	1.1	40	0.6	6,209	98.3	6,317
19	0	0.0	38	1.0	25	0.7	3,645	98.3	3,708
29	4	0.5	14	1.9	7	1.0	711	96.6	736
30	9	0.9	16	1.6	5	0.5	956	97.0	986
31	6	1.8	23	6.8	2	0.6	306	90.8	337
Aug 1	7	2.0	16	4.5	0	0.0	334	93.6	357
5	7	0.5	13	0.9	7	0.5	1,349	98.0	1,376
6	8	0.9	6	0.7	2	0.2	856	98.2	872
16	89	0.6	47	0.3	36	0.3	14,081	98.8	14,253
21	76	0.4	40	0.2	40	0.2	18,903	99.2	19,059
23	375	1.4	64	0.2	26	0.1	25,752	98.2	26,217
28	119	0.7	34	0.2	37	0.2	16,859	98.9	17,049
Sep 4	156	0.9	184	1.1	116	0.7	16,109	97.2	16,565
23	165	1.2	89	0.6	15	0.1	13,698	98.1	13,967
Oct 3	635	4.5	114	0.8	10	0.1	13,349	94.6	14,108

Table 3. Age composition of Great Black-backed Gulls recorded at the Robin Hood Bay Landfill (27 June-3 October 1996).

		Young-of-year		1st year		2nd year		3 years+		Totals
Date		N	%	N	%	N	%	N	%	
June	27	0	0.0	82	21.4	88	23.0	213	55.6	383
July	4	0	0.0	709	51.7	228	16.6	434	31.7	1,371
	11	0	0.0	249	37.6	128	19.3	285	43.1	662
	19	0	0.0	163	37.5	40	9.2	232	53.3	435
	29	0	0.0	44	42.7	10	9.7	49	47.6	103
	30	0	0.0	83	50.6	7	4.3	74	45.1	164
	31	0	0.0	40	56.3	0	0.0	31	43.7	71
Aug	1	0	0.0	47	54.0	2	2.3	38	43.7	87
	5	19	14.5	14	10.7	0	0.0	98	74.8	131
	6	14	15.6	6	6.7	0	0.0	70	77.8	90
	16	176	4.9	72	2.0	13	0.4	3,315	92.7	3,576
	21	146	4.8	4	0.1	24	0.8	2,857	94.3	3,031
	23	357	9.1	28	0.7	45	1.1	3,493	89.0	3,923
	28	237	7.7	16	0.5	13	0.4	2,817	91.4	3,083
Sep	4	337	5.5	50	0.8	41	0.7	5,688	93.0	6,116
	23	158	6.7	22	0.9	14	0.6	2,166	91.8	2,360
Oct	3	349	10.4	47	1.4	8	0.2	2,938	87.9	3,342

Herring Gull

Herring Gulls nested on coastal cliffs both north and south of the landfill and on the outer cliffs of Small Point (Figure 3). After fledging, small groups of young-of-the-year Herring Gulls were found on the water at the base of the cliffs along Green Gulch, Small Point and Bobbies Cove (see Figure 3 for locations). During these observations on 28 July, the gulls stayed very close to shore.

According to landfill staff, it is possible that some adult Herring Gulls attempted to nest at the landfill (i.e. on the hillside of area H). However, none of the birds was observed to be successful.

Interestingly, it appears that some adult Herring Gulls eat rats. On one occasion, an adult Herring Gull was seen flying, with great difficulty, away from area D with half a rat hanging out of its mouth.

Great Black-backed Gull

This species was often seen in tall grass and on sloping banks (e.g. in areas E and H). Great Black-backed Gulls may also have attempted to nest at Area H. However, there was no evidence of successful nesting.

Great Black-backed Gulls were observed feeding on rats at the landfill. The birds were large enough to swallow the rats whole. The rat population was very large judging by the numbers of observations, particularly at night and at dawn and dusk. In fact, on at least some occasions, gulls spent the entire night on the landfill.

Other Gulls

Three first summer Glaucous Gulls were present at the landfill from 27 June to 23 September. A single yearling Iceland Gull was present at the landfill on 30 July and 1 August. Two Lesser Black-backed Gulls (an adult and a sub-adult) were seen on 23 September in Areas B and T.

The Black-legged Kittiwake is a pelagic gull that nests along the coastal cliffs to the north and south of the landfill. Kittiwakes were seen flying along the cliffs and out to sea, but they were never seen over or at the landfill.

Although Ring-billed Gulls were not uncommon in the St. John's area, they were not recorded at the landfill during this study. They were present at several other locales in the area. These are noted later in this report.

Raptors

A pair of Northern Goshawks nested in the trees NW of Sugarloaf Pond; they produced at least one offspring. An adult and a young Goshawk were seen hunting in the NW part of the landfill just before sunrise on 5 August. There were three other sightings at the landfill during this study.

One or two Sharp-shinned Hawks were occasionally seen flying over the landfill. Even a small raptor like the Sharp-shinned Hawk can cause the gulls at the landfill to flush into the air.

Bald Eagles were often seen at the landfill. Gulls on the ground responded with a panic reaction when the large Bald Eagle flew near, or over, them. Almost daily an eagle would stir up the gulls at the landfill. Gulls towered into the air in response to the eagle. This created a potential hazard to incoming aircraft that were angling over the landfill to assume an approach to Runway 29. On warm, clear days, gulls can tower up to several thousand feet above ground; at times aircraft were observed flying through these flocks of gulls.

At least one pair of Bald Eagles nested in the vicinity of the landfill in 1996. The nest was thought to be in the Redcliff area to the north of the landfill. The nesting was likely successful as indicated by the three young-of-the-year eagles (most likely siblings) that were seen in the trees around Area H on 16 October; the eagles were being mobbed by crows.

American Crow

More than a thousand crows flew into the landfill from the NW every morning. They fed in all areas of the landfill particularly around the edges of the active disposal areas. They were often seen in large numbers during the day in the trees in Area Y or north of Area D or in the wet Area G

(see Figure 3 for locations). After the landfill closed at 16:30, the crows flew NW to a night roost in coniferous trees between Logy Bay and the Airport.

Common Raven

Few ravens were seen foraging or loafing at the landfill. Most often they were seen flying over the trees on the northern slope of the landfill or soaring along the eastern cliffs by Green Gulch and Small Point. They also frequented the trees between Green Gulch, Bobbies Cove and the White Hills.

European Starling

European starlings were common at the landfill. Although detailed censuses were not conducted, a few thousand starlings were present every day. Flocks numbering in the hundreds used most parts of the landfill, especially Areas D, G, a, X and Z (see Figure 3 for locations). Many of these starlings were juveniles; some individuals were eaten by Herring Gulls and Great Black-backed Gulls. Once, a young-of-the-year Great Black-backed Gull was seen swallowing a juvenile starling that had been feeding on the ground beside it.

DAY-USE AREAS

A series of four lakes and ponds located within a few km of the Robin Hood Bay Landfill were used by the gulls that fed at the landfill. These waterbodies included Sugarloaf Pond, Virginia Lake, Newfound Pond, and Windsor Lake. They were used for loafing, bathing and drinking by gulls that travelled back and forth between these day-use sites and the landfill.

Sugarloaf Pond

The numbers of gulls observed using Sugarloaf Pond are tabulated in Table 4. The numbers present ranged from 4 on 1 August to 599 on 13 August when the gulls returned from the sea. Herring Gulls and Great Black-backed Gulls were the only species identified there. Throughout the day, there was a constant turnover of gulls at the pond.

Large numbers of gulls travelled between nesting and roosting areas in the Logy Bay and Redcliff Head areas and the landfill. A high proportion of these gulls stopped at, or passed over,

Table 4. Numbers of gulls using Sugerloaf Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Unid. Gull	Totals	
July	3	17:00	65	5	0	20	90
	4	16:30	73	7	0	0	80
	9	12:45	28	6	0	32	66
	11	16:45	130	45	0	100	275
	12	06:00	25	11	0	0	36
	15	12:15	90	15	0	50	155
	16	16:15	130	10	0	0	140
	18	09:00	24	3	0	0	27
		16:30	present	present	0	present	100
	19	10:30	10	1	0	0	11
	21	13:15	40	3	0	0	43
	23	14:45	65	4	0	0	69
	30	14:15	25	2	0	0	27
Aug	1	11:30	3	0	0	1	4
	3	16:50	8	0	0	0	8
	5	10:45	21	2	0	0	23
	6	10:50	31	1	0	0	32
	13	17:25	262	37	0	300	599
	15	14:20	192	68	0	0	260
	21	13:10	61	25	0	100	186
	27	13:40	127	53	0	50	230
Sep	3	17:20	170	120	0	0	290
	6	12:25	193	57	0	0	250
	19	15:30	54	226	0	0	280

Sugarloaf Pond during these flights. For example, a total of 4,451 gulls entered the landfill from the direction of Sugarloaf Pond during a three hour period at dawn on 26 June. During the day, gulls also used Sugarloaf Pond as a way point on flights between the landfill and Virginia Lake (see Figure 1 for locations). These movements often involved gulls towering high into the air before gliding on set wings to the next location.

Virginia Lake

Few gulls used Virginia Lake as a day-use site during the nesting season. Numbers of gulls present in late June to late July period ranged from 3 to 44 (Table 5). However, after the gulls returned from the sea in mid August, large numbers used Virginia Lake. Numbers in the last half of August ranged from 207 to 583, but they increased to over 1,400 in September (Table 5). Herring Gulls comprised 90% of the identified gulls at Virginia Lake. On three occasions, 2 Ring-billed Gulls were present on the lake.

As at Sugarloaf Pond, there was high turnover of gulls at Virginia Lake. Gulls flew into the lake from the east, i.e. from the landfill, settled for a few minutes and then flew further west toward the Airport and Windsor Lake or returned eastward toward the landfill. There was a steady stream of gulls flying east or west over the lake. Often towering flocks of gulls would develop over the lake and then drift either east or west.

Newfound Pond

Newfound Pond is located between the Airport and Windsor Lake and can be reached by trail from the NE corner of Windsor Lake off Portugal Cove Road. It is a small sheltered pond with tall coniferous trees all around its shore. Typically, only a few gulls were seen here, with the exception of 78 on 12 July and 370 on 19 September (Table 6). Gulls either settled on the water or on a small beach on the SE part of the pond. Gulls were often seen in small numbers flying E or SW over this pond. Herring and Great Black-backed Gulls were the only gull species identified at Newfound Pond.

Windsor Lake

Windsor Lake is a major day-use area that is used for loafing, bathing and drinking by Herring Gulls and Great Black-backed Gulls. The numbers of gulls present at the lake during the

Table 5. Numbers of gulls using Virginia Lake as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Unid. Gull	Totals
June 26	18:45	6	1	0	2	9
July 9	18:00	4	2	0	1	7
11	17:30	5	2	0	0	7
12	10:05	7	0	0	37	44
15	14:55	1	1	0	1	3
21	12:55	0	0	0	3	3
23	16:50	0	0	0	3	3
29	10:30	0	0	0	0	0
Aug 3	12:10	0	0	0	0	0
15	12:00	101	9	0	97	207
21	12:00	338	62	0	131	531
22	15:40	361	29	2	100	492
27	16:40	461	39	0	83	583
Sep 3	16:35	174	24	2	99	299
6	11:35	1,109	141	2	200	1,452
19	16:10	1,230	95	0	0	1,325

Table 6. Numbers of gulls using Newfound Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Unid. Gull	Totals
July 9	19:10	0	0	0	1	1
12	12:45	34	36	0	8	78
15	17:00	0	0	0	0	0
17	10:00	11	13	0	10	34
23	12:00	1	0	0	1	2
Aug 12	13:55	0	0	0	0	0
15	11:05	0	0	0	0	0
18	17:40	8	6	0	16	30
21	09:55	0	0	0	14	14
Sep 3	16:00	0	0	0	6	6
19	16:50	277	93	0	0	370

nesting season through mid July were relatively small ranging from 9 to 135 gulls (Table 7). The numbers began to increase in mid August with peak numbers present on 27 August (1,400) and 17 September (1,700). Herring Gulls represented 81% and Great Black-backed Gulls 19% of the identified gulls at Windsor Lake. Only a single Ring-billed Gull was recorded at the lake; a juvenile on 18 September, during a non-systematic survey.

The numbers of gulls present at one time underestimated the numbers that used Windsor Lake on any particular day. For example, four surveys of the lake at four different times on 17 September recorded totals of 183, 700, 560, and 1,700 gulls (Table 7). From mid August onward, there was a constant movement of gulls to and from the lake. The largest movements were to and from the east, toward Virginia Lake and the landfill. Others moved west toward the west end of the lake and onward towards Portugal Cove or St. Phillips on the shore of Conception Bay. The latter movements include the flights to the night roost at Little Bell Island in Conception Bay. On clear days, gulls were seen towering very high (up to an estimated 2,000 feet) and drifting in spirals over Windsor Lake.

Ponds West of Windsor Lake

Ten ponds and small lakes that have road access are located to the west and southwest of Windsor Lake. They are Olivers Pond, Hughs Pond, Mitchells Pond, Hogans Pond, Healeys Pond, Gull Pond, Powers Pond, Butlers Pond, Murrays Pond, Millers Pond (not mapped). The ponds were occasionally visited (17 and 24 July and 4 August) although not all ponds were visited on each day. The numbers of gulls present at any of these ponds on these mid day counts ranged from 0 to 3. The exceptions were the aptly named Gull Pond where 130 and 13 gulls were loafed on a small island on 17 and 24 July, respectively and Hogans Pond which supported 66 gulls on 17 July. Gulls flew over these ponds en route between Windsor Lake and Conception Bay.

Western Island Pond

Western Island Pond is located NW of the Airport (see Figure 1); it can be reached from Indian Meal Line following a path at "Trails End" leading to a scout camp by the pond's northerly shore. This pond was visited on 17 and 24 July and 12 August when 5, 1 and 1 gulls were present, respectively. A single adult Great Black-backed Gull was present each day and 4 adult Herring Gulls were present on 17 July.

Table 7. Numbers of gulls using Windsor Lake as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Unid. Gull	Totals
Junc 25	18:30	-*	-	-	-	50
28	05:00	-	-	-	-	9
	06:00	-	-	-	-	29
	07:00	45	5	0	15	65
July 3	18:00	0	0	0	10	10
9	18:40	30	15	0	17	62
12	13:30	-	-	-	-	50
13	15:30	-	-	-	-	50
15	16:30	-	-	-	-	135
	20:00	-	-	-	-	5
	21:00	-	-	-	-	35
17	11:00	9	32	0	6	47
23	11:30	3	1	0	3	7
24	15:30	-	-	-	-	9
29	11:00	-	-	-	-	2
Aug 4	18:00	0	0	0	0	0
12	12:55	257	88	0	0	345
15	09:30	27	55	0	6	88
18	17:20	0	0	0	6	6
	18:20	0	0	0	5	5
21	09:30	19	16	0	42	77
23	18:15	-	-	-	-	600
27	17:30	1,029	71	0	300	1,400
Sep 3	15:00	47	30	0	8	85
17	11:45	128	55	0	0	183
	13:00	-	-	-	-	700
	14:00	-	-	-	-	560
	15:30	-	-	-	-	1,700
18	15:30	-	-	-	-	335
	17:45	-	-	-	-	452
19	16:30	-	-	-	-	700
27	19:00	-	-	-	-	200

* - indicates that species composition was not determined on this census.

Quidi Vidi Lake

During the winter, Quidi Vidi Lake was a major loafing area for thousands of gulls that used the Robin Hood Bay Landfill, 2-3 km away (see Davis and Macravis 1995 for details). The lake was not heavily used by gulls during the summer. The results of 15 censuses from 26 June to 19 September are presented in Table 8. Significant numbers of gulls were not seen until mid August when large numbers returned to the St. John's area. Numbers built up in late August and September until there were 1,621 gulls present on 19 September (Table 8).

It was clear that not all of the gulls that were present at Quidi Vidi Lake in summer were associated with the landfill. For example, substantial numbers (up to 600) of Ring-billed Gulls were present at the lake in August and September (Table 8). During the same period, Ring-billed Gulls were not recorded at the Robin Hood Bay Landfill (Table 1).

In July, a few gulls frequented the beach at the eastern end of the lake where birds were being fed. When these gulls left the lake, they flew east through Quidi Vidi Gut to the ocean or south over Georges Pond to St. John's Harbour. By mid August, gulls were also found on the beach in the south-western corner of the lake from where they flew back and forth to the East End Sewage, in St. John's Harbour. Ring-billed Gulls often loafed on the parking lot west of the lake or on the adjacent grassy soccer field. Herring Gulls and Great Black-backed Gulls loafed on the grassy fields and softball diamonds on the northern shore of Quidi Vidi Lake. There was a differential distribution of age groups at the lake. On 19 September, the gulls on the beach at the eastern end of the lake were exclusively young-of-the-year (125 Herring Gulls and 19 Great Black-backed Gulls), whereas the adults were to be found on the lake or on the northern fields.

A single yearling Glaucous Gull hung around the eastern beach at Quidi Vidi Lake until 21 August. A single yearling Iceland Gull was seen on the northern fields on 21 August.

Quidi Vidi Gut

Herring Gulls and Great Black-backed Gulls nest in large numbers on the cliffs of Cockold Head along the coast south of Quidi Vidi Gut. Gulls are constantly visible here flying north and south over the nearshore Atlantic Ocean. Gulls also fly east and west through Quidi Vidi Gut. The numbers of gulls actually using this body of water were fairly small (Table 9).

Table 8. Numbers of gulls using Quidi Vidi Lake as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Other	Totals
June 26	19:10	37	0	5	1*	43
July 9	20:00	0	0	0	0	0
10	16:00	7	2	1	0	10
11	17:45	0	0	0	0	0
15	10:00	28	0	3	1*	32
21	13:30	14	0	0	0	14
23	17:10	0	1	0	0	1
29	11:30	2	0	0	0	2
Aug 1	11:40	0	1	0	0	1
3	12:30	0	0	0	0	0
13	16:40	57	18	52	1*	128
21	08:00	173	6	80	2**	261
22	17:20	169	37	114	0	320
29	12:00	85	199	140	0	424
Sep 19	12:45	858	164	599	0	1,621

* Glaucous Gull.

** One each of Glaucous Gull and Iceland Gull.

Table 9. Numbers of gulls using Quidi Vidi Gut as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Unid. Gull	Totals
June 26	19:15	10	0	0	20	30
July 10	15:30	42	2	0	19	63
15	10:30	20	0	0	0	20
21	13:40	-*	-	-	-	40
23	17:15	-	-	-	-	60
Aug 1	11:45	41	0	0	0	41
3	12:45	51	0	0	0	51
13	17:00	37	3	0	0	40
21	08:20	46	4	3	0	53
22	17:50	30	1	0	0	31
Sep 19	13:20	-	-	-	-	30

* - indicates that species composition was not determined on this survey.

Georges Pond

Georges Pond is a small backup freshwater reservoir for St. John's. It is located on Signal Hill and provides a stopover for Herring Gulls and Great Black-backed Gulls flying between Quidi Vidi Gut and St. John's Harbour. The pond was regularly used by substantial numbers of gulls (Table 10). Numbers present seemed to be higher later in the day and later in the season. Numbers peaked at 415 on 15 October.

St. John's Harbour

The main gull attractions in St. John's Harbour were the two sewage outflows into the harbour. Most of the gulls seen in the harbour loafed on the roof of a warehouse building west of the northern corner of the harbour and fed where the East End open sewage outlet runs into the harbour. A smaller group of gulls fed at the Harbour Drive Sewage outlet in the southwest part of the harbour. Gulls were also often dispersed in small numbers throughout the harbour and also were regularly seen to fly in and out of the Narrows connecting the harbour with the Atlantic Ocean.

The numbers and species of gulls recorded in St. John's Harbour are itemized in Table 11. Numbers present were fairly consistent (about 50-150) from late June through late July. Few gulls were present in the late July through mid August period, a period when gulls had also vacated the Robin Hood Bay Landfill. Gulls returned to the harbour in mid August and about 450 were present through to mid September (Table 11).

In the early summer, Herring Gulls and Ring-billed Gulls were the most common species in the harbour. Also present were upwards of 50 Black-legged Kittiwakes (Table 11). The kittiwake is a pelagic gull that was not recorded at any of the inland sites. Kittiwakes were last seen in the harbour on 13 August. Small numbers of Black-headed Gulls appeared at that time. In mid August, the numbers of Ring billed Gulls peaked at 295 on the 13th. The numbers slowly declined to 138 on 19 September (Table 11). During the mid August to mid September period, the numbers of Herring Gulls and Great Black-backed Gulls increased steadily, reaching peaks of 265 and 84, respectively, on 19 September (Table 11).

Starting in mid August, a flightline developed between the north end of the St. John's Harbour and Quidi Vidi Lake. There was a steady stream of Ring-billed Gulls and Herring Gulls flying between the East End sewage outlet and the western beach at Quidi Vidi Lake.

Table 10. Numbers of gulls using George's Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Totals
July 10	15:00	127	7	0	134
11	10:30	12	2	0	14
15	09:45	4	1	0	5
16	12:45	149	11	0	160
21	09:45	11	3	0	14
23	17:30	142	4	0	146
Aug 1	11:55	18	0	0	18
3	09:50	21	6	0	27
13	15:40	278	62	0	340
22	10:45	78	26	2	106
Sep 19	12:00	53	158	0	211
Oct 15	16:10	75	340	0	415

Table 11. Numbers of gulls using St. John's Harbour as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Blk-legged Kittiwake	Totals
June 26	19:45	-*	-	-	-	90
28	18:35	8	1	38	15	62
29	09:30	6	0	55	10	71
July 2	18:00	20	6	77	5	108
9	20:10	11	1	15	12	39
10	16:20	26	4	44	14	88
14	14:15	99	5	23	50	177
17	09:20	14	3	23	5	45
21	09:55	14	0	18	4	36
23	17:50	24	3	14	7	48
30	17:00	3	0	8	0	11
Aug 2	16:30	0	0	3	0	3
3	10:05	0	0	1	0	1
5	13:35	8	1	16	0	25
11	19:00	26	28	165	6	225
13	15:00	69	28	295	8**	400
22	11:30	195	55	194	1**	445
29	11:00	202	70	154	2**	428
Sep 19	11:00	265	84	138	0	487

* - indicates that species composition was not determined on this survey.

** - includes 2 Black-headed Gulls on 13 Aug., 1 on 22 Aug., and 2 on 29 Aug.

Long Pond, Burtons Pond, Kents Pond and Kennys Pond

This series of small ponds is located on a line WSW of the Robin Hood Bay Landfill (see Figure 1). The ponds were surveyed 8-10 times from 27 June to 19 September. Relatively small numbers of gulls used these ponds during the summer. Small numbers of Herring Gulls and Ring-billed Gulls used Kennys Pond in late August and early September (Table 12). At 30 birds, the peak number present was not large.

In 10 visits to Kents Pond, only 3 Herring Gulls were noted; two on 27 June and one on 19 September.

Burtons Pond was used only by Ring-billed Gulls (Table 13). These birds were present in late June and from mid August through mid September. The highest number recorded at Burtons Pond was 18 Ring-billed Gulls.

Very small numbers of gulls frequented Long Pond during the summer and early fall (Table 14). Herring and Ring-billed Gulls were present but the highest number recorded was only 3 birds.

Mundy Pond

Mundy Pond was used by gulls throughout the late June to mid September study period, although numbers increased toward the end of the period (Table 15). Herring Gulls and Ring-billed Gulls were the main species involved. The Ring-billed Gulls often loafed on the grass on the baseball diamond SW of the pond and the Herring Gulls and an occasional Great Black-backed Gull were often seen on the water, near the north shore.

Bowring Park

Gulls were present at the ponds at Bowring Pond through the summer (Table 16) with nearly 100 present in late August. The most common species was the Ring-billed Gull with smaller numbers of Herring Gulls, particularly later in the season. The waterfowl and gulls at Bowring Park are frequently fed by park visitors.

Table 12. Numbers of gulls using Kennys Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Totals
June 27	13:00	1	0	0	1
July 9	19:45	0	0	0	0
10	18:00	0	0	0	0
21	11:40	0	0	0	0
24	15:00	0	0	0	0
Aug 3	11:50	0	0	0	0
12	10:50	0	0	3	3
21	08:50	1	0	3	4
22	15:20	0	0	10	10
Sep 19	13:30	11	0	19	30

Table 13. Numbers of gulls using Burtons Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Totals
June 27	12:45	0	0	8	8
July 10	17:30	0	0	0	0
21	11:20	0	0	0	0
24	14:40	0	0	0	0
Aug 3	11:30	0	0	0	0
12	09:30	0	0	6	6
22	15:00	0	0	11	11
Sep 19	13:50	0	0	18	18

Table 14. Numbers of gulls using Long Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Totals
June 27	12:30	0	0	0	0
July 10	17:30	0	0	0	0
21	11:00	1	0	0	1
24	14:50	1	0	0	1
Aug 3	11:30	0	0	0	0
12	09:10	0	0	0	0
22	14:40	2	0	0	2
Sep 19	14:00	1	0	2	3

Table 15. Numbers of gulls using Mundy Pond as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Totals
June 27	11:45	28	0	4	32
July 10	17:15	3	0	1	4
21	10:45	10	1	0	11
24	10:00	6	1	2	9
Aug 3	11:15	0	0	0	0
13	09:15	7	1	16	24
22	14:00	26	0	27	53
Sep 19	14:10	56	1	2	59

Table 16. Numbers of gulls using Bowring Park as a day-use site during summer/early fall, 1996.

Date	Time	Herring Gull	Great Black-backed Gull	Ring-billed Gull	Totals
June 28	17:45D*	5	0	6	11
July 10	17:00D	0	1	1	2
21	10:30D	**	.	.	10
24	10:35D	0	0	0	0
Aug 3	10:45D	0	0	0	0
13	12:45D	2	0	10	12
	12:15F	2	0	19	21
22	13:10D	25	0	48	73
	13:30F	2	0	20	22
Sep 19	14:40D	24	0	39	63
	15:50F	2	0	4	6

* D = Duck Pond; F = Fountain Pond.

** - indicates that species composition was not determined on this census.

GULL NIGHT ROOSTS

Gulls spend the night in dense flocks at communal night roosts in locations where they are safe from terrestrial predators. The locations of night roosts are traditional and are used year after year. Gulls often fly long distances (several tens of km) between the night roosts and major daytime feeding sites, such as landfills. Thus, it is necessary to determine the locations of the night roosts in order to understand gull movement patterns in an area.

Coastal Roosts

Most of the gulls that feed at the Robin Hood Bay Landfill roost at night along the Atlantic Coast to the east of the landfill. Flight paths between these roosts and the landfill do not approach the airport and consequently, they do not have any effect on the safety of aircraft using the St. John's Airport. Thus, little effort was expended trying to determine the exact locations of roosts along the coast. During the nesting season, most gulls roost at and near the cliffside nesting colonies. The gulls from the coastal night roosts enter the landfill through Bobbies Cove, Green Gulch, and a route south from Logy Bay that enters the NW corner of the landfill property. The use of the various flight paths is discussed in a later section (see GULL MOVEMENTS).

Robin Hood Bay Landfill

Although gulls are often present at landfills before sunrise in the morning and after sunset in the evening, it is very rare for gulls to actually spend the night and roost at a landfill. The situation at the Robin Hood Bay Landfill is somewhat unique in that the landfill does not support terrestrial predators such as foxes, coyotes and wild dogs. Similarly, there are no owls present in the St. John's area during the summer. Thus, some gulls roosted at the landfill at night during the summer. On 28 June, there were still several thousand gulls present at the landfill at 22:20 (~1.5 h after sunset). On 19 July, about 4,000 gulls were present at the landfill at 04:30, one hour before sunrise and before gulls had started to fly into the landfill. Using night vision binoculars, it was possible to determine that about 80% of the gulls in the tall grass of Areas P and O (see Figure 3) were adult Great Black-backed Gulls feeding on rats that were abundant at the landfill. Adult Herring Gulls roosted in tight flocks in Areas B and C.

Observers searched the landfill intensively from 02:00 to 05:00 (sunrise at 05:26) on the night 6 August. Altogether, over 500 gulls were present at the landfill: 100+ on the hillside of area H and

400+ in a tight group on the flats of dried compressed soil west of "Red Shack" (area A and B). The latter flock was facing into the light NW wind. At 05:15, 200 of these gulls could be seen clearly and consisted of 181 adult Herring Gulls, 14 adult and 4 young-of-the-year Great Black-backed Gulls and a single first summer Glaucous Gull.

The evidence strongly indicates that a few thousand gulls actually roosted at the Robin Hood Bay Landfill at night during the nesting season. This night roosting was not found during the fall and winter study in 1994-95.

Conception Bay

The studies in the fall and winter of 1994-95 found that there was a night gull roost at Little Bell Island in Conception Bay (see Figure 1). Many of these gulls fed at the Robin Hood Bay Landfill passing through airport Approach/Departure paths en route (Davis and Mactavish 1995).

During the present study, gulls nested and roosted at Little Bell Island. On 13 and 14 July, the NW cliffs and upper grassy plateau of Little Bell Island were observed from Lance Cove Head on Bell Island. About 2,000 Herring and Great Black-backed Gulls were seen loafing, nesting, and roosting there. In the three hours before sunset (at 20:45), 2,625 gulls were seen flying into the beach and pool on the SE corner of the island, probably coming from the northeast in the direction of St. Phillips. St. Phillips is due west of Windsor Lake.

On 12 September, gulls were observed arriving at Little Bell Island between 16:30 and 19:30 (sunset 19:19). The observations were made from Chamberlains, south of Little Bell Island. A total of 1,902 gulls were observed arriving from the northeast. The gulls flew SW into the same beach on Little Bell Island at the south end of the island. All of these observations were made at distances of about 3.5 km and thus, they should be treated as very minimal estimates of numbers.

The numbers of gulls that made daily return flights between the Little Bell Island roost and the Robin Hood Bay Landfill in the late August-September period are estimated in the following sections.

GULL MOVEMENTS

When gulls are present on the landfill, they do not pose a hazard to the safety of aircraft using the St. John's Airport. It is when gulls fly to and from the landfill, and tower over the landfill, that the potential for safety hazards can be created. These flight paths are examined in this section.

Gull Arrival/Departure Patterns at Landfill

Gulls began arriving at the landfill before sunrise. They arrived from five different directions over the course of the study. Gulls arrived from the ocean to the east by flying over Green Gulch and Bobbies Cove (see Figure 3). On the west side of the landfill, gulls arrived over the NW corner, over the landfill entrance, and over "Indian Rock" by the large gravel pit to the southwest (Figure 3).

Green Gulch

Observations of arriving and departing gulls over Green Gulch were made in the early mornings of 19 July and 6 August. On 19 July, observations were made at Green Gulch over a 4 hour period from 04:30 to 08:30 (sunrise at 05:26, first gulls between 05:15 and 05:30). During this 4 h period, 764 gulls entered and 999 gulls left the landfill. Similarly, 4 h of observations were made at Green Gulch from 04:45 to 08:45 on 6 August (sunrise 05:45). On this date 141 gulls entered the landfill and 517 exited. On both days more gulls left the landfill through Green Gulch than arrived by this route. Gulls leaving the landfill settled on the outer cliff-ledges of the gulch or on the water below, or the gulls flew south around Small Point.

Not many gulls arrived at the landfill from the north through Green Gulch. The gulls that nested on the northern cliffs of Logy Bay, the coast of Redcliff Head and Torbay Point entered the landfill by an inland route that headed directly south from Logy Bay (see later).

Bobbies Cove

Bobbies Cove is a low pass between the landfill and the Atlantic Ocean (see Figure 3). This is a major passageway for gulls entering and leaving the Robin Hood Bay Landfill. On 26 June, observations were made here from 05:10 to 08:05 (Sunrise at 05:00). During this period, 3,202 gulls entered the landfill through Bobbies Cove and 2,085 gulls left the landfill. These observations were repeated at the very end of the nesting season on 6 August 1996. During the 4 h between 04:45 and

08:45. 1,676 gulls entered the landfill and 493 exited it. The smaller number of leaving gulls probably reflects the fact that most young gulls had left their nests by this time and the adults did not return to the nest to feed them.

Throughout the day during the nesting season there was a steady movement of gulls into and out of the landfill through Bobbies Cove. These gulls were thought to roost and nest on the cliffs along the coast south of the landfill. Often, when the gulls at the landfill were flushed, large numbers of them streamed out of Bobbies Cove either to land on the water close by or fly south along the coast.

Northwest Corner

A major gull flightline entered the landfill at its northwest corner. Gulls using this flightline apparently flew on a line between the landfill, Sugarloaf Pond, and Logy Bay (see Figure 1). The birds using this route apparently nested on cliffs from Logy Bay north to Redcliff Head and Torbay Point. Gulls flying out of the landfill to Sugarloaf Pond chose a route slightly to the east of the aforementioned, and then either landed on the pond to loaf, bathe and drink before flying onward, or joined the circling gulls over the pond before flying north toward Logy Bay, or west toward Virginia Lake. The flight path of gulls between Sugarloaf Pond and Logy Bay was well observed from Marine Lab. Road, and from Sugarloaf Road between Sugarloaf Pond and the landfill.

Gulls were observed from the NW Corner of the landfill from 05:10 to 08:05 (sunrise 05:00) on 26 June. During this period, 4,451 gulls arrived from the north and 782 gulls departed to the north from this corner of the landfill. Observations were made at the same location from 05:00 to 08:45 (sunrise 05:43) on 5 August. By this time nesting was virtually completed and many gulls had left the St. John's area for a few weeks. Only 138 gulls arrived and 165 departed during the observations on 5 August.

Landfill Entrance

Observations were made at the landfill entrance at the west end of the landfill. Gulls flying straight west from the landfill entrance would first reach Virginia Lake, about 2 km away and then the south boundary of the airport, about 5 km away.

Few gulls arrived at the landfill via the Landfill Entrance and Virginia Lake. Observations of departing gulls were made from 20:25 to 21:50 on 28 June; 30 gulls entered the landfill and 185 exited the landfill during this 85 minute period. Observations were made from 04:30 to 08:30 (sunrise 05:26) on 19 July. Only 85 gulls arrived, and 41 departed, via the Landfill Entrance during this 4 h period. The morning observations were repeated from 05:00 to 08:45 on 5 August when only 24 gulls arrived and 7 departed via the Landfill Entrance. It was clear that gulls from nesting areas to the west of the landfill were not feeding at the landfill during the nesting season.

Indian Rock

'Indian Rock' is an elevated observation point at the SW corner of the Robin Hood Bay Landfill. Although systematic observations of gulls were not made from 'Indian Rock' during the nesting season, it was clear that few gulls were approaching the landfill from the SW at this time. This situation changed later in the study (see following section).

'Indian Rock' is located by a large gravel pit and an old cement plant. Very few gulls loaf on this gravel pit during the summer months whereas the gravel pit is heavily used by loafing gulls on occasion during the winter.

Late Summer/Early Fall Period

Gull use of the landfill changed after the nesting season and after the gulls returned to the St. John's area in mid August. On 15 August, observations were made from 'Indian Rock' from 15:30 to 17:45. This vantage point allowed the observer to also see all birds entering via the main Landfill Entrance. During this 135 minute observation period, 7,285 gulls flew west out of the landfill, while only 180 gulls entered via these routes.

On 30 September, an extended watch was conducted from 'Indian Rock'. Continuous observations were made between 06:40 and 12:00 and between 12:30 and 16:45. Numbers passing during the 30 minute break were extrapolated by averaging the numbers in the 30 minutes prior to, and just after, the break. The observations were terminated at 16:30 because of the onset of heavy rain that made observations impossible. An estimated total of 11,082 gulls entered the landfill from the west during these observations; an estimated total of 4,549 gulls left the landfill and flew to the west. Substantial numbers of gulls were still present in the landfill when the observations were terminated.

It is apparent that there was a substantial two-way movement of gulls between the landfill and Virginia and Windsor lakes during the day. This was indicated by the steady stream of gulls into the landfill throughout the day. The numbers arriving by 2-hour period were 1,705, 2,127, 2,017, 2,356 and 2,877. The corresponding numbers for departures were 266, 212, 596, 1,396 and 2,079. Thus, during the first six hours, 5,849 gulls arrived at the landfill from the west compared with only 1,073 leaving to the west. This confirms other information that indicates that several thousand (about 4,000 to 5,000) gulls that roost at Little Bell Island in Conception Bay fly east to feed at the Robin Hood Bay Landfill during the late summer and fall. During the last four hours, 5,233 gulls arrived at the landfill and 3,475 left the landfill. This suggests that in the afternoon, there is more of a back-and-forth movement between the landfill and Windsor/Virginia lakes.

The turnover of gulls at the landfill is confirmed by observations at nearby Virginia Lake, 2 km to the west. There is a constant turnover of gulls at Virginia Lake. Some gulls coming from the landfill fly back to the landfill after loafing, bathing and drinking at the lake; others fly on west along the main gull flight path south of the Airport to Windsor Lake. From Windsor Lake many gulls fly back east after loafing, bathing and drinking, but some fly on to the lakes west of Windsor Lake, to Portugal Cove and especially out through St. Phillips to the night roost at Little Bell Island in Conception Bay.

St. John's Airport

Gull flight paths near the St. John's Airport were monitored from the Terminal Parking Lot at the south end of Runway 02/20 on the south side of the airport property. This vantage point allowed good coverage of the gull flightline between the Robin Hood Bay Landfill and Virginia Lake in the east and Windsor Lake/Newfound Pond and Conception Bay in the west.

Early morning observations were made from the airport parking lot from 04:50 to 07:20 (sunrise at 05:04) on 28 June 1996. During this 2.5 h period, only 11 gulls flew east toward the landfill and 29 flew west toward Windsor Lake. Clearly, this flight path was not being used by gulls late in the nesting season. A single Common Loon passed to the northwest over the airport at an elevation of about 100 m during the observation period.

By late August, the east-west flight line past the airport was being used by gulls. Observations were made from the parking lot from 06:00 to 09:00 on 29 August. During this 3 h period, 3,670 gulls flew east past the airport and 260 gulls flew west. The main eastward movement

of gulls did not begin to pass the airport until about 07:15, one hour after sunrise. This suggests that the gulls originated at a distant night roost, such as Little Bell Island about 19 km away. Thus, the major eastward movement of gulls represented birds travelling to the landfill from the night roost at Little Bell Island in Conception Bay. The gulls followed a route about 500 m south of the airport and flew at altitudes of 10-60 m above ground. At 07:45, 16 gulls (young-of-the-year Herring [8] and Ring-billed [8] Gulls) were present on the middle of Runway 16/34. By 08:35, the numbers on the runway had increased to 24 gulls. These gulls were scared off the runway by taxiing aircraft.

In order to quantify the gull movements past the south side of the airport, all day watches were made from the airport parking lot on 11 and 29 September. Observations began at 06:00 on 11 September and continued until 19:50. Thus, observations began before sunrise at 06:33 and continued until after sunset at 19:21. Since these observations were made by a single observer, there is a 30 minute break in the middle of the day. Also, rain and fog prevented observations between 09:15 and 09:45. The numbers of gulls passing during these two periods were extrapolated using the average of the numbers in the half hour periods on either side of the breaks. In addition, fog inhibited observations for two periods of 45 and 30 minutes. Thus, some gulls were missed during these periods but there is no obvious way of correcting for these small underestimations.

Observations on the 11th were made over a 13 h and 50 min period. During this period, 6,885 were estimated flying east toward the landfill and 9,053 were estimated flying west toward Windsor Lake and beyond. The periods with fog and reduced visibility occurred in the morning when most gulls observed were flying eastward. Thus, the numbers flying to the east are probably underestimated relative to the numbers flying to the west. The net directions of the flying gulls changed through the day. During the first third of the day (06:00-10:30), a total of 3,421 gulls flew east toward the landfill while only 200 flew west toward Windsor Lake. These eastward moving gulls were apparently travelling to the landfill from their night roost at Little Bell Island in Conception Bay. During the middle third of the day (10:30-15:00), 1,767 gulls flew east and 3,000 gulls flew west past the airport parking lot. Many of these birds were travelling to Windsor Lake to loaf and wash in fresh water before returning to the landfill. In the last third of the day (15:00-19:50), 1,697 gulls moved east toward the landfill and 5,853 gulls moved west toward Windsor Lake and beyond. The data suggest that about 4,000 gulls from the roost in Conception Bay fed at the Robin Hood Bay Landfill. The rest of the gulls were probably involved in local movements between the landfill and Windsor Lake. The overall significance of these daylong observations on 11 September is that a total of at least 15,938 large gulls passed through the aircraft Approach paths to Runways 34 and 2 and the Departure paths from Runways 16 and 20.

The specific route followed by the gulls seemed to be determined by the direction and strength of the wind. On the morning of 11 September, the wind was from the south at about 20 km/h and most gulls were passing over airport property, just south of the Terminal Building at altitudes of about 20-40 m above ground (agl). This route took the gulls very close to, or over, the south ends of Runways 16/34 and 2/20. Later in the day, gulls flew at higher altitudes ranging from 20 to 120 m agl with some towering up to 200 m agl.

Observations were made from the airport parking lot from 06:30 to 17:30 on 26 September and from 15:30 to 18:50 (sunset at 18:45) on 27 September. The results of the surveys from 17:30 to 18:50 on the 27th were added to the results for 26 September to attain coverage for the entire daylight period. Overall, an estimated total of 12,026 gull flights were observed from the airport parking lot: 4,379 heading east and 7,647 heading west. North winds were prevalent on the 26th and 27th so that the gulls were about 0.5 to 1 km south of the observation point. Some gulls may have passed undetected at these longer distances. During stronger north winds late on the 27th, the gulls were passing between 1 and 1.5 km to the south.

GULL USE OF ST. JOHN'S AIRPORT

In addition to the gulls that flew through the aircraft Approach/Departure paths at the south end of the airport, gulls often landed at the airport where they loafed and fed. Gull use of the airport was highly seasonal.

Airport staff conduct hourly sweeps of the runways to insure that they are clear. The numbers of gulls seen are recorded. Records were examined for the period September 1994 to March 1997, inclusive. The data for the period July 1995 to November 1995 are missing. The monthly gull totals are shown in Figure 4. It is clear that the biggest problems occur from late May through June. Smaller peaks occurred in September and October. The numerical data in Figure 4 should not be construed to represent the actual numbers of gulls present at the airport. The data are only useful for identifying those periods when large numbers of gulls occur often. The presence of zero or small numbers for a particular month does not necessarily mean that no gulls occurred at the airport during this month. For example, we observed gulls many times at the airport in July 1996, one take-off was aborted because of gulls on 16 July, and pilots complained about the numbers of gulls at the threshold of Runway 34 in the morning and afternoon of 11 July. However, no gulls were reported during the hourly sweeps for July (Figure 4).

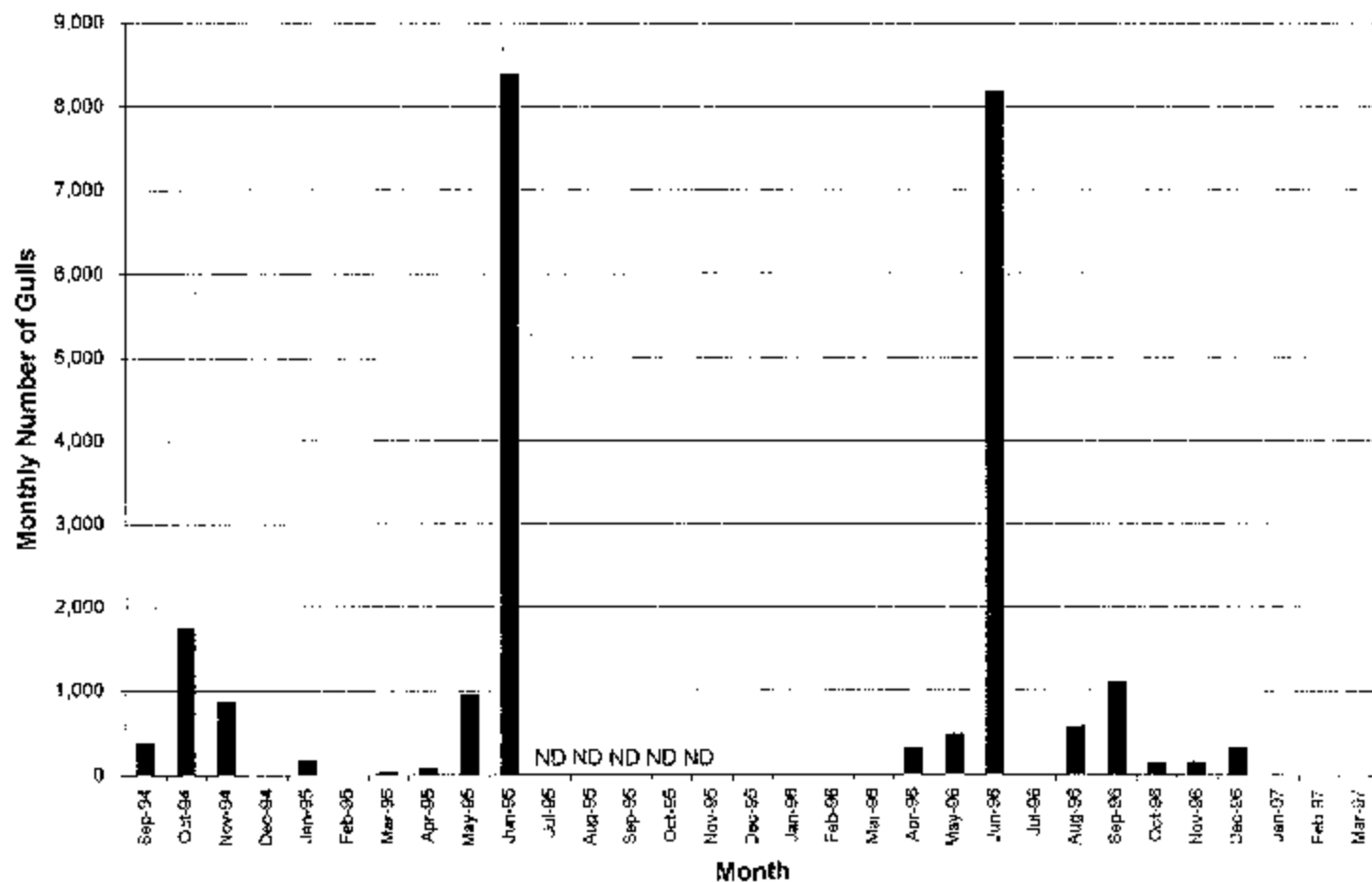


Figure 4. Monthly totals of hourly gull observations by ground staff at St. John's Airport from September 1994 to March 1997. (Columns with ND indicate no data were available for that month. Blank columns indicate that data were available but that no gulls were recorded.)

In addition to the Herring Gulls and Great Black-backed Gulls from the landfill that sometimes landed on the airport, there was a small group of about 15 Ring-billed Gulls that spent the day at the airport from mid August into September. These were mostly young-of-the-year birds. These Ring-billed Gulls caused quite a bit of trouble. We observed from the Control Tower from 09:00 to 11:00 on 6 September. At 09:00, Ring-billed Gulls were loafing on the closed Runway 08/24. The tower personnel notified ground staff to move these gulls. The gulls flushed as the pick-up truck approached and left the immediate area. However, the gulls landed on other active runways: 3 landed on Runway 16/34 and 6 landed on Runway 20/2. At 09:40, the Captain of an Air Nova Dash 8-100 reported that his aircraft had struck gulls when landing on Runway 16. The runway was closed while ground staff searched the runway for signs of dead birds. None were found and the runway was re-opened. At 10:13, the Dash 8 returned to Runway 34 to commence take-off. However, there were 4 gulls on the runway and the Captain asked that they be removed before take-off. The gulls were moved and the aircraft took-off 8 minutes later.

The previous incident illustrates two important points. First, it is difficult to control birds at airports and sometimes control efforts in one area can create more serious hazards in other parts of the airport unless appropriate precautions are taken. Second, many of the problems with gulls at the airport in late August and September were caused by Ring-billed Gulls. This species was not associated with the Robin Hood Bay Landfill but probably came from Quidi Vidi Lake or St. John's Harbour or from one of the other day-use areas such as Mundy Pond, Burtons Pond and Bowring Park. Problems with Ring-billed Gulls will persist regardless of what control measures are implemented at the Robin Hood Bay Landfill.

There is a creek about 100 m south of the Control Tower in which Black Ducks nest and Ospreys fish; Northern Pintails were also found there. A few shorebirds, e.g. 'peeps', Black-bellied Plover and Greater Yellowlegs were at times seen along, or on, the runways. Daily, flocks of 10-60 American Crows and 60-300 European Starlings were seen at various locations throughout the area of the airport. A few times, a Merlin and a Bald Eagle were seen flying over the airport.

GULL FLIGHT PATHS

The principal bird hazards to aircraft created by gulls are determined by the major flight paths used by gulls flying among nesting colonies and night roosts, feeding locations such as landfills, and major loafing areas. The study reported here covered two major stages of the gull's life cycle: the nesting season and the late summer post-nesting period.

Gull Nesting Season

The major gull nesting colonies in the St. John's area occur south of the landfill along the coastal cliffs on the eastern side of Small Point, Cuckold Head and St. John's Bay and north of the landfill on the cliffs of Logy Bay, Redcliff Head and Torbay Point. Birds from the north generally arrived and departed the landfill from the NNW over Sugarloaf Pond. The main access to and from the southern colonies was via the southeast corner of the landfill over Bobbies Cove (Figure 5). During the nesting season, adult gulls do not remain at the landfill for the day, but rather move back and forth between the landfill and their nesting colonies. For example, during a watch from 05:15 to 08:00 on 26 June 1996, a total of 3,202 gulls arrived at the landfill through Bobbies Cove, while 2,085 gulls left the landfill, presumably to return to their young at nests in the colonies to the south.

During the nesting season, there were only small numbers of gulls at inland locations. The flight line between Little Bell Island in Conception Bay and the landfill was not used at this season. Only small numbers of gulls used Virginia Lake (average of 4 gulls on 7 surveys from 26 June to 23 July) and Windsor Lake (average of 36 gulls on 11 surveys from 25 June to 23 July) during the nesting season.

During the nesting season, the major gull flight paths are short and the gulls travel between the Robin Hood Bay Landfill and the ocean coast. Thus, gull flight paths create minimal hazards to aircraft safety during the gull nesting season.

Late Summer/Early Fall

When large numbers of gulls returned to the St. John's area in mid August, they established major inland movement patterns that were maintained until the study terminated in early October. Twice daily flights between the night roost at Little Bell Island and the Robin Hood Bay Landfill were re-established. In addition, there were movements between the landfill and loafing areas on Windsor Lake, Newfound Pond, and Virginia Lake. Many of the gulls flying to Windsor Lake and Newfound Pond stopped at Virginia Lake on the way. These flight lines are illustrated on Figure 6.

These east-west flights contained substantial numbers of gulls. For example, nearly continuous observations at the west end of the landfill from 06:40 to 17:45 on 30 September revealed an estimated 11,081 gulls arriving from the direction of Virginia Lake to the west and 4,549 gulls returning in that direction. Heavy rain terminated these observations. Observations were made from

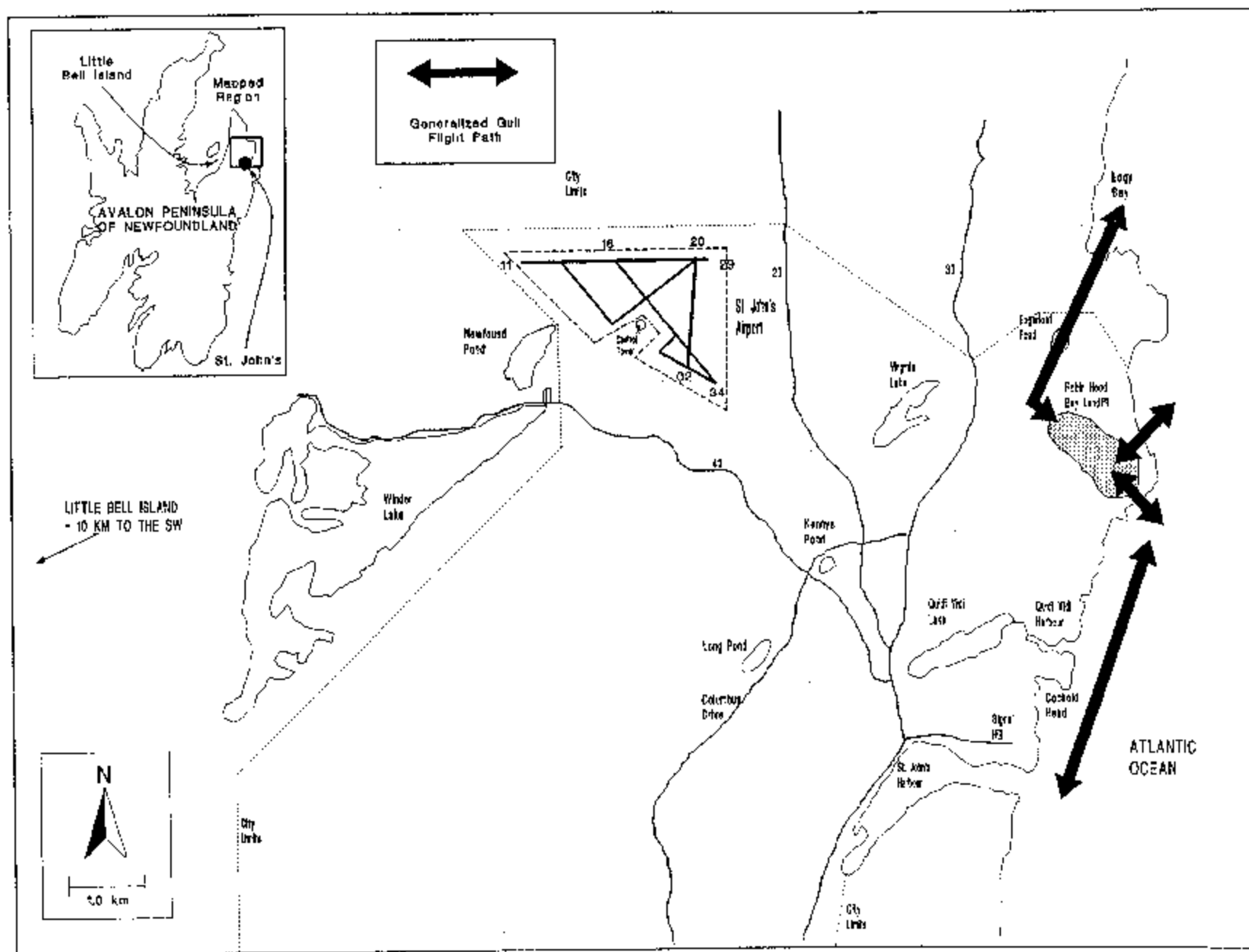


Figure 5. Stylized representation of the principal gull flight paths in the St. John's region during the gull nesting season (late June-July).

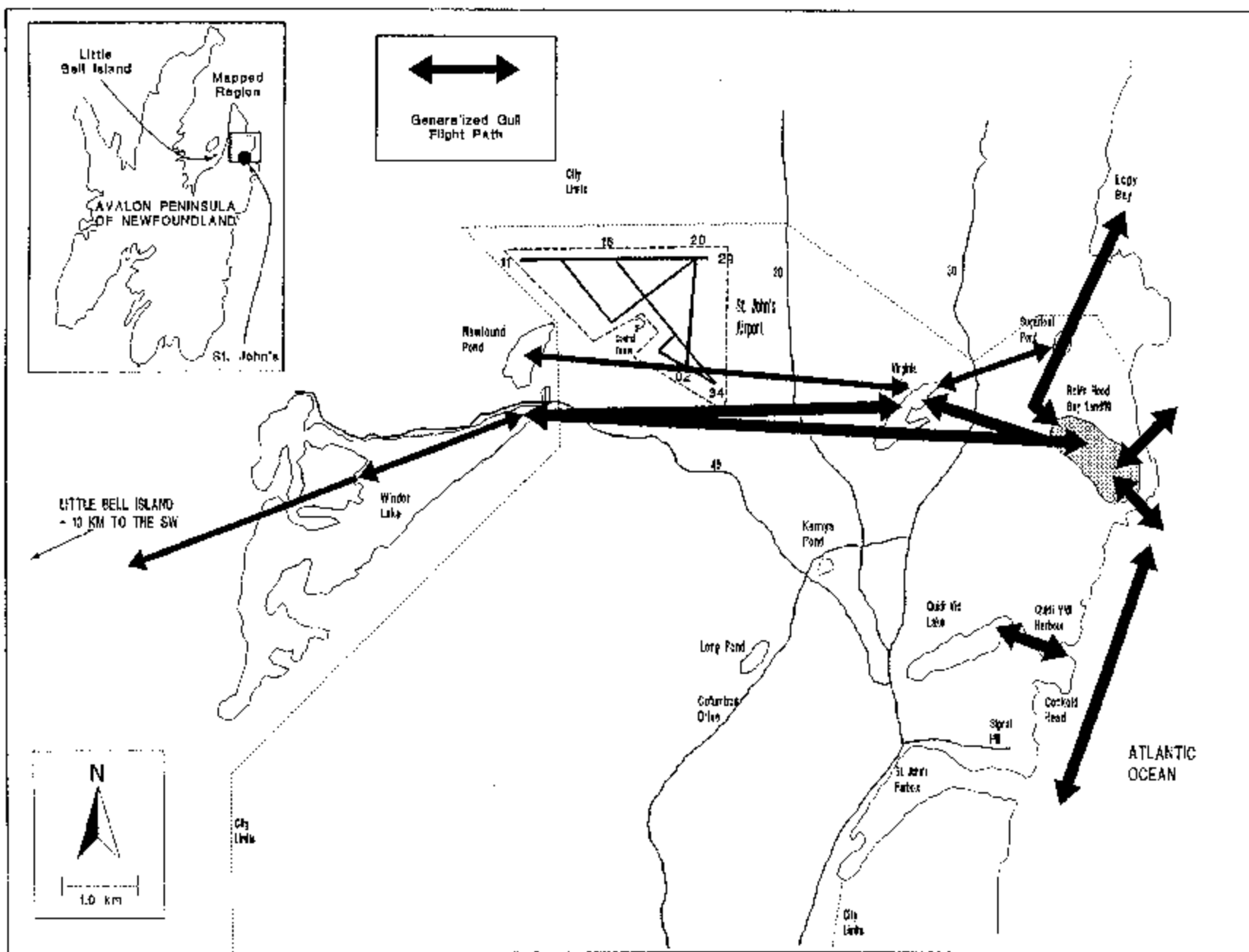


Figure 6. Stylized representation of the principal gull flight paths in the St. John's region in late summer and early fall.

the parking lot at the passenger terminal at the airport from 06:00 to 19:50 on 11 September. An estimated 6,885 gulls flew east and 9,053 flew west. Similar observations were made from 06:30 to 17:30 on 26 September and 17:30 to 18:50 on 27 September. On these dates, a total of 4,379 flew past to the east and 7,647 passed to the west. Thus, over 16,000 and 12,000 gulls passed through the Approach Paths to Runways 02 and 34 on the two full days that were sampled.

The actual flight paths followed on these east-west flights depend partly upon the wind direction. On 11 September, a 20 km/h south wind pushed the gulls north so that they were passing just south of the terminal parking lot and close to the south ends of Runways 16/34 and 20/2. On 27 September, a strong north wind caused the gull flightline to be 1 to 1.5 km south of the airport. Depending upon cloud cover, time of day, temperature and wind, the gulls could be anywhere from a few m above ground to several hundred m agl.

On 26 September, light aircraft from the flying school made repeated take-offs into the south wind and through flocks of passing gulls. On at least one occasion, a gull was observed taking sudden avoidance actions to avoid the aircraft. Of greater concern is the situation when there is low cloud and a turbine-powered aircraft on final approach lets down through the cloud and encounters a flock of gulls that did not see the approaching aircraft. A significant hazard would be created.

SUMMARY AND CONCLUSIONS

The results of this study and the preceding study in the November 1994 to March 1995 period are combined in an Executive Summary that is bound with this report. Rather than repeat information here, the reader is referred to that summary for the integrated results and interpretation of the two studies. The Executive Summary contains a series of recommendations for addressing the significant bird hazard to aircraft safety that has been documented.

ACKNOWLEDGEMENTS

We thank Mr. Harold Hefferton and Mr. Jim Roche of the St. John's Airport for allowing us access and for providing information. We also thank the many controllers at NavCanada that provided assistance and information in the airport control tower. Similarly, ground personnel at the airport provided assistance. Mr. Paul Mackey and Mr. David Blackmore of the St. John's Department of Public Works kindly allowed us access to the Robin Hood Bay Landfill and provided

information about the facility. Staff members at the landfill were also very helpful. Bruce Mactavish provided information on local gull populations.

We thank Bruce MacKinnon of the Aerodrome Safety Branch of Transport Canada in Ottawa for funding this study and for his interest in insuring that the findings were reliable and addressed air safety concerns.

Staff at LGL Limited who contributed to the report included Bev Griffen, Ted Elliott and Kathleen Hesser

APPENDIX 40

**The Globe and Mail, Friday, January 2, 1998:
Think owls are bad?**

Think owls are bad?

In August, 1924, the Niagara Falls Gazette reported that an eagle with a wingspan of 2.4 metres hoisted 14-year-old Fred Cun-



ningham, who weighed 44 kilograms, off a golf course near Chatham, Ont., and carried him 1.5 metres before the lad's clothing gave way. He fought with the bird, adds Paul Sieveking

of the Fortean Times, and forced it against a wire fence, where a man killed it.

Thought du jour

"Owls teach us wisdom and sagacity and not to put our hands into hollow trees." — U.S. humorist Will Cuppy, in paraphrase.

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APPENDIX 41

Plane and Pilot, February 1998: Bird Strike



By Bill Cox

Bird Strike!

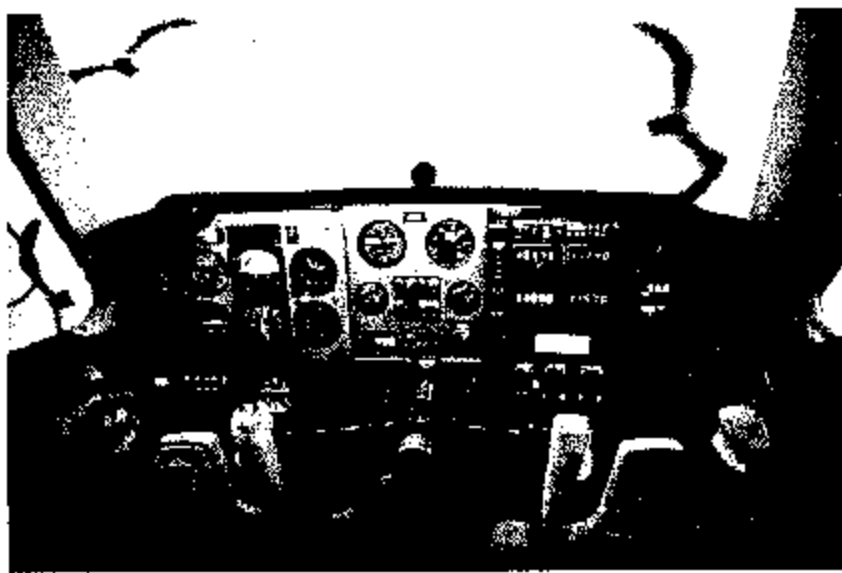
Avoiding our avian friends isn't always easy, usually because we can't see them or maneuver out of the way fast enough

Sometimes, you make your own luck. Twenty years ago, while flying across the California desert at 500 feet AGL in a company Seneca II (legal but ill-advised), I slammed into something big, possibly a duck or hawk. Whatever it was came at me in a black blur, impacted the nose of the Seneca, bounced off the windshield, left blood and feathers behind, ricocheted off the de-ice boot on the vertical stabilizer and disintegrated into space. Thank God, it didn't come through either prop.

To my amazement, there was no damage to the airplane. The bird had hit on a sharply tapered section of the resilient fiberglass nosecone and, though the impact sounded almost like a dull shotgun blast, the blow had been so glancing that the fiberglass was undamaged. The paint wasn't even cracked. I hosed the airplane down back on the ramp, and you couldn't tell there'd ever been a strike.

Fast forward to 1997. I was flying a new 1998 Piper Saratoga HP to Bendigo, Australia, near Melbourne. After four days on the ocean, I'd cleared customs in Brisbane at noon, hopped over to Archerfield for fuel and had elected to overnight in Dubbo, 400 nm southwest and about 350 miles north of Melbourne. It was spring in Australia, the weather was great and the new Piper had been running perfectly from Vero Beach, Fla., all the way across the Pacific.

I'd cruised in smooth air and sunshine



Digital Creation by James Law & Co.

at 6500 feet on the short, 2½-hour hop across from Archerfield and had let down to 2500 feet to enter the pattern at Dubbo. Nothing unusual, just another short flight at the end of several long ones.

I was reaching for the gear handle when there was another of those dull thuds I'd heard once before. I knew I must have hit something, but I couldn't see any evidence of damage from the left front seat. The airplane continued to fly normally but, just to be safe, I abbreviated the pattern and turned directly for the threshold of runway 23.

On the ground, it was apparent I had indeed suffered a bird strike, this time something really big, possibly a vulture. Whatever it was came through the prop at the seven o'clock position, bounced off the bottom left cowling, was deflected two feet out to the left wing where it crashed in the bottom of the alt cabin air vent and departed beneath the left wing at about the gear station. I don't dwell on "what ifs," but had I extended the gear a

second sooner, it might have been in transit at the time of impact and who knows what problems might have resulted.

The damage was bad enough. Though the resilient fiberglass lower cowling suffered only scuffed paint, two blades of the Saratoga's three-blade prop were essentially history. The tips were badly dinged where the bird had come through, and the air vent was badly dented. After a full power runup the following morning, it

was apparent the airplane was still flyable, and I continued the trip the last 350 miles to Bendigo.

The owner was a prince about the problem and didn't blame me, the insurance investigator simply shrugged and said, "A bird strike is a bird strike," but I still felt terrible for delivering a brand-new 1998 Saratoga HP 10,000 nm in less than perfect condition.

Truth is, there's virtually nothing you can do to avoid a bird strike other than not to be where they are. Pretty obviously, the risk is greater at lower altitude, but tall heights are no guarantee against an unexpected encounter. Years ago, I saw what may have been a condor soaring at 15,000 feet while I was flying across the Sierra Nevada, and other pilots have reported seeing eagles as high as 18,000 feet over the Rockies.

The greater danger obviously is during migration season in the flyways of the world. Here in the United States, there are five primary routes: the Atlantic

Coast route, the Mississippi flyway, the Central flyway down the flat center of the United States, the Pacific flyway down California's San Joaquin Valley and the Pacific Coast route. Spring and fall are the critical times when birds are migrating north and south, respectively.

Individual birds generally are too small to see, no matter what their size, even in the best of weather. (Several years ago, I participated in some FAA tests of a satellite-based TCAS system, and one peripheral conclusion was that even experienced pilots flying in perfect weather are unlikely to spot a full-sized airplane outside of one mile.) If you encounter a flock of birds in flight, at least you're more liable to spot their greater mass than you would a single bird.

Assuming you do spot one or more birds in time to take evasive action, the cardinal rule is to avoid flying beneath them. Birds tend to dive when alarmed, so you should either plan to pass above them or turn away early enough to avoid underflying a flock.

Unless you fly a Pitts, Sukhoi or Extra, you'll stand almost no chance of outmaneuvering a bird. With closure speeds as high as 350 feet per second, your chances of even seeing a bird before impact are virtually nil. The bird I hit impacted below the spinner, so I probably wouldn't have seen it even if I'd been looking straight ahead rather than reaching for the gear lever.

My bird strike happened in September in Southern Australia, spring in that part of the world. That's migration season, when birds are flying north for the Australian summer. In retrospect, I'm not sure there's anything I could have done differently. Admittedly, I wasn't looking for birds when I entered the pattern at Dubbo. Perhaps I should have read the final notice on Dubbo Airport in the Australian en route supplement, however. "Caution: Bird and animal hazard exists." P&P

P&P senior editor Bill Cox has made approximately 75 international aircraft deliveries in everything from Skyhawks to the Swearingen SJ-30 business jet, and offers aircraft delivery, aircraft positioning and international copilot service. For more information, write: Plane & Pilot, Attn: Bill Cox, 12121 Wilshire Blvd., Suite 1200, Los Angeles, CA 90025.