Final Report of the Research on Avian Protection Project (2010 – 2014)

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RAPP
Research on Avian Protection Project

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Preface

Despite the single authorship of this report, the *Research on Avian Protection Project* was conducted as a collaborative, multidisciplinary project that involved dozens of other individuals in academia, industry, and government who worked toward a common goal of increasing bird protection in the oil sands region of Alberta.

This report synthesizes the results of that work, which includes several independent components completed over the past few years by me and other members of the RAPP team. These other components include (a) reports on specific incidents or programs that have been submitted previously to government and industry, (b) protocols or training material for use by industry, (c) manuscripts that have been or will be submitted to peer-reviewed journals, and (d) theses by graduate students. Associated documents are introduced in the chapters that follow. Most documents are already available in their entirety on the RAPP website (http://rapp.biology.ualberta.ca/), but others will appear there later. In particular, manuscripts intended for peer-reviewed journals will be posted after acceptance of their final versions. Theses submitted to the University of Alberta library may be embargoed for six months to protect primacy of publication.

Some of the information contained in this final report is new, but much of it summarizes the preceding documents described above. Anyone making reference to the information contained in this report should cite the titles and authors of the original documents when possible. Information that is not contained in other documents and the entire report can be cited as follows.

C. C. St. Clair. 2014. Final Report on the Research on Avian Protection Project. Prepared for Alberta Justice, Edmonton, Canada.

Questions about this report may be directed to Colleen Cassady St. Clair (cstclair@ualberta.ca) at any time.

Cover photo of a Horned Grebe by Dave Fairless

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Acknowledgements

I am grateful for the opportunity to lead the Research on Avian Protection Project and to the many individuals and organizations who supported it.

Susan McRory and Ron Kruhlak, who co-proposed the creative sentence and this research project, taught me much about collaborative and constructive outcomes of litigation. I have appreciated their ongoing guidance and the more recent support of Hanneke Brooymans and Craig Kallal.

I thank the RAPP Advisory Committee, David Fairless, John Gulley, Joel Ingram, and Darrell Martindale, for dedicating many hours via conference calls and an in-person meeting in the winter of 2010-11 to the planning of RAPP objectives, and for providing periodic and very helpful guidance thereafter in both structured and informal ways.

I am deeply grateful to the graduate students, Elizabeth Beck, Ffion Cassidy, and Sarina Loots, who undertook M.Sc. projects to support RAPP's objectives. These students were dedicated throughout to the highest possible standard of work to advance avian protection, often at the cost of very long hours. That goal was also supported by several undergraduate students who dedicated fresh ideas and tireless effort to independent research projects: Joelyn Kozar, Mallory Nault, Paul Nelson, Steve Pasichnuk, and Patrick Welsh (2011); Seann Murdock, Stephan Pacholak, and Sierra Sullivan (2012).

I appreciated the excellent work by several undergraduate assistants and interns who supported RAPP in the courses of their degrees: James Koether, Victoria Lemmons, Stephan Pacholok, Tyana Rudolfsen, Sierra Sullivan and Carissa Wasyliw. Several others who had recently completed undergraduate degrees provided capable assistance in both field and laboratory work: Fauve Blanchard, Amanda Brown, Katrina Burrows, Alicia Cappello, Allison Dunlop, Amy Field, Neil Foley, Michelle Fornier, Lindsay Howes, Julia Jackson, Steven Pasichnuk, Tobias Tan, Nicole Woodman, and Sarah Yuckin. Most of these students were local, but Neil Foley followed his passion for birds from upstate New York specifically to work on RAPP after hearing about it at a conference. High school students Emily Barlow-Bolch, Natalie Hervieux, Rachel Nay, and Irina Simin assisted us as part of the WISEST (Women in Scholarship, Engineering, Science and Technology) summer research program.

I could not have managed the hefty administrative and data management load of RAPP without the professional assistance of many excellent technicians: Jeff Ball, Aditya Gangadharan, Chris Godwin-Sheppard, John Brzustowski, Trish Fontaine, Patrick Gilhooly, Tom Habib, Cindy McCallum, Bryan Shore, and Donnette Thayer. Cindy

McCallum went far, far beyond the call of duty to support this project – and many other aspects of my life—while I recovered from a concussion in Spring 2013.

Several of my academic colleagues enhanced the RAPP project and student experiences by giving generously of their expertise including Erin Bayne and Keith Tierney of my own Department of Biological Sciences, Naomi Krogman of the Department of Resource Economics and Environmental Sociology, and Hong Zhang of the Department of Computing Sciences. Distant collaborators included Rob Ronconi and Phil Taylor of Acadia University and Judit Smits of the University of Calgary.

The standardized monitoring program was a collaborative effort that benefited from the hard work of many industrial colleagues: Cal Duane, Joanne Hogg, and Sarah Robertson (CNRL); Hanna Janzen, Rachel Nobel-Pattison, and Sherry Nugent (Imperial); Chelsea Hoff, Paul Knaga, Fred Kuzmic, and Darrell Martindale (Shell); Bruce Anderson, Christine Lambert, and Josh Martin (Suncor); Courtney Drover, Steve Gaudet, and Jamie Sullivan (Syncrude). In turn, these companies were supported by dozens of other individuals who collected monitoring data. Equally important to that collaborative program were the contributions of several government employees: Michael Aiton, Randall Barrett, Pat Marriott, Andrea McGregor, Sarah McLean, Tanya Richens, Joann Skilnick, Kelly Williams, all of the Government of Alberta, and Joel Ingram and Richard Wiacek of the Government of Canada. I especially appreciated the dedication and vision of Sarah McLean. The entire group spent dozens of hours creating and refining a standardized, rigorous, and comparable monitoring program that can support evidence-based deterrent practices in future, ultimately supporting better bird protection.

In addition to financial support from the court order, our work on avian protection received important logistical assistance from Shell Canada Limited and Imperial Oil Limited who provided access to their sites for our experiments with automated monitoring, and financial support in the form of an NSERC (Natural Science and Engineering Research Council) Industrial Postgraduate Scholarship (Shell) and a research grant (Imperial). The Fedun family provided a cozy home for our captive ducks and Tim Lewyk of The Lewyk Camp generously donated camping space, power, and water throughout our 3 years of fieldwork. Our work was also supported by the University of Alberta and by NSERC via a Discovery Grant (to C. C. St. Clair) and a Canada Graduate Scholarship (to E. Beck).

Finally, I am grateful to my family – JC, Grayson, Kieran, Liam and Erica—without whose love, patience, and humour, I could not have done the work I did on RAPP, nor could I have enjoyed it as much. Thank you for tolerating over-zealous descriptions of bird vision, treks to muddy, bud-infested wetlands disguised as Sunday outings, and my enduring, quirky interest in 'oily ducks.'

Executive Summary

The Research on Avian Protection (RAPP) emanated from a creative sentence that followed the conviction of Syncrude Canada Limited for failing to provide adequate protection from a hazardous substance for migratory birds. As one part of the creative sentence, the research project was intended to increase avian protection in the mineable oil sands and was guided by specific objectives to (1) create a compendium of relevant information, (2) support a standardized monitoring program of bird contacts with process-affected water produced by the industry and associated mortality, (3) conduct field experiments to identify mechanisms of risk, and (4) recommend best practices for the industry in future.

With a team of graduate students, technicians, undergraduate assistants, and colleagues in industry, government, and academia, I addressed those objectives between November 2010 and April 2014. The report that follows describes the products of our work in 13 chapters that correspond, approximately, to the four objectives of the project. Because our work has been completed mainly via several more specific products, such as reports, thesis chapters, and drafts of peer-reviewed publications, this report contains two kinds of information. A brief narrative introduces the origin of each chapter and describes the content of associated documents, from which one or more sections may be excerpted. Complete copies of those documents and the appendices are available on the RAPP website (http://rapp.biology.ualberta.ca/).

***Compendium of information**.* Chapter 1 provides information on RAPP including its origin, objectives, advisory structure, collaborator and duration. Information is also provided on the structure of this report and background to the problem of bird protection in the mineable oil sands. The chapter concludes with brief annotated bibliographies of key references for several topics; historical literature, standardized monitoring, automated monitoring, deterrence, and toxicology. Our complete bibliography of approximately 2,000 documents is available on the website.

Chapter 2 summarizes a report I completed with the assistance of Bryon Shore and Tom Habib at the request of the Government of Alberta on the mortality of birds following mass landings on October 25, 2010. That work resulted in new hypotheses about the combined effects on bird vulnerability caused by four weather, darkness, proximity to a riverine corridor, and anthropogenic light in the vicinity of bitumen.

Chapter 3 summarizes a media analysis led by a former undergraduate student, Paul Nelson, in collaboration with Naomi Krogman and Lindsay Johnston. This work shows the dramatic increase in media attention to the issue of tailings ponds following the landing event in 2008. It further shows how that coverage was concentrated on the statements of a few politicians, industry leaders, and one environmental group with little representation by the public.

Support for a standardized monitoring program. In 2010, the Government of Alberta announced the requirement for industry to create and adhere to a standardized protocol for monitoring contact and mortality of birds associated with process-affected water ponds. Industry asked me to refine that plan and to receive, examine and report on the data from it.

Chapter 4 summarizes the successive refinements we made to the monitoring plan in 2011, 2012, 2013 and 2014 in collaboration with representatives from government and industry. Bird monitoring has transitioned from paper-based records of unstandardized procedures to a single protocol that is employed by all five companies with surface mines. Surveys are conducted with consistent training, methods and equipment at specific locations, frequencies, and durations; the data from them is entered directly to electronic databases in the field.

Chapter 5 describes two annual reports we produced from the standardized monitoring program as a service to government and on behalf of industry. In lieu of a similar report with the 2013 data, I have provided as appendices to this report a series of tables, maps and figures that complement and extend similar products from previous annual reports. Using a database we homogenized, industry produced their own monitoring reports in 2013. We will synthesize the 2013 data and compare it to previous years as the basis of a peer-reviewed publication.

The standardized program, which is now known as the *Oil Sands Bird Contact and Monitoring Program*, has demonstrated that tens of thousands of waterbirds (defined in this context as birds that wade, dabble, or dive to obtain food) land each year on the process-affected water ponds produced by the mineable oil sands industry, but very few appear to die as a result. Because these birds potentially migrate to destinations throughout North America, this result is likely to shift environmental concerns about migratory birds in the oil sands region from mortality to contamination.

Conduct field experiments. Field experiments addressed three themes—automated monitoring, toxicology and deterrence—as M.Sc. research projects by Sarina Loots, Elizabeth Beck, and Ffion Cassidy, respectively.

Chapter 6 contains a summary of Sarina's thesis, which explored the potential to use automated cameras to monitor birds and the effects of camera resolution and frame rate. She also assessed the use of marine radar for bird detection and investigated the effects of antenna type, installation height, substrate type, and bird characteristics. Her results suggest that cameras could augment and replace some monitoring by humans in the standardized program and that radar fails to detect many of the birds that are detected by human observers.

Chapter 7 describes Elizabeth's thesis work, which includes a literature review of the effects of process-affected water from the mineable oil sands on birds. Although there has been considerable work on the effects of hydrocarbons on birds more generally, very little work addresses the level of exposure experienced by wild birds that use process-affected water occasionally without contacting bitumen. To emulate that exposure, Elizabeth subjected domestic ducks, a sub-species of mallard, to process-affected water collected from an industrial recycle water pond. She took blood samples from these birds and ones that were similarly treated with well water, and compared several metrics. There were few differences in the two groups of birds, but the metal vanadium was significantly higher in treated birds.

Chapter 8 summarizes Ffion's experiments with a variety of visual deterrents that might be used to supplement the current emphasis on auditory deterrents in the oil sands. She focused her efforts on two kinds of deterrents; lasers that targeted specific individuals and stationary devices that differed in their presumed ecological context and degree of realism. Her work will be completed later this year, but preliminary results suggest that the effect of lasers is specific to laser colour and ambient light, as well as the species, sex, and age classes of target birds. Her preliminary results on deterrents suggest that birds readily habituate to most visual deterrents but that motion and ecological relevance increase responsiveness by birds.

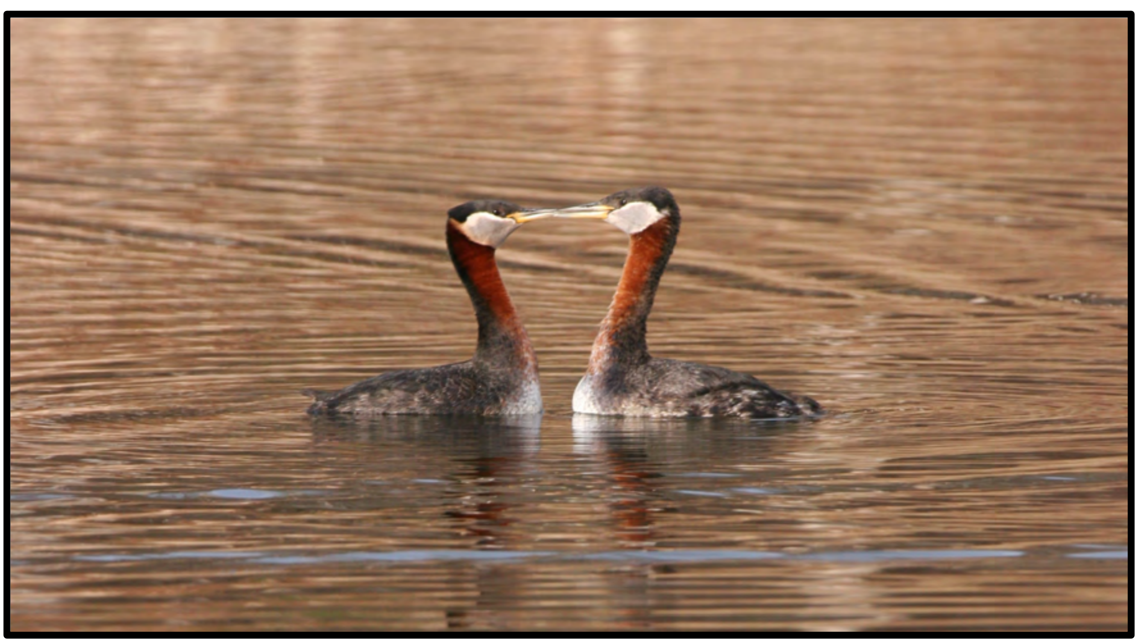
In addition to these three graduate projects, seven undergraduate students conducted independent research projects that addressed aspects of avian protection and supported related work by graduate students (Chapter 9).

Chapters 10 and 11 provide accounting information. In Chapter 10, I identify the many forms of knowledge exchange that emanated from RAPP, including training for students, development of professional biologists, collaboration with individuals in academia, government, and industry, and many forms of public engagement. Chapter 11 explains how the RAPP funds were allocated. A majority of the funding supported salaries for students and technicians; the remainder was allocated to equipment, travel and field expenses, and laboratory analyses.

Recommend best practices. All of our work was intended to support better practices for bird protection in the mineable oil sands and plausible recommendations stem from each of the chapters described above. Those recommendations are summarized in Chapter 12 in two ways. A table of operational recommendations is organized around a series of short statements that illustrate perspectives that were prevalent at the beginning of our work. These are followed by a description of the relevant information provided by RAPP and one or more recommendations that logically emanate from them. These recommendations are intended to provide starting points for discussion and further investigation; work on some of them is already underway. Three more holistic and philosophical recommendations are described in a short essay.

The final chapter, 13, offers some musings on my experience in leading RAPP. The work by graduate students was diverse and logistically challenging, but it was consistent with the kind of work done in other contexts by both professors and students. From its combination of generous funding and trans-disciplinary questions, RAPP provided unusually rich research opportunities that afforded excellent topics for thesis work.

Our work on the standardized monitoring program, and our *de facto* role in leading change by industry and government, was less conventional. Aspects of this unusual collaboration were effective in advancing bird protection very rapidly. But this arrangement also produced awkward dependencies on our work for regulatory permits, which strained its collaborative intent and imposed difficult time constraints. Despite those challenges, our combined efforts have positioned the mineable oil sands industry as a global leader in bird monitoring. With that information, it will be able to identify best practices for bird deterrents across the mineable oil sands to emerge as a respected global leader for evidence-based bird protection at industrial sites.



Courtship display of red-necked grebes. Photo by Dave Fairless

Section 1

Background to the Research on Avian Protection Project

Mats of floating vegetation are frequently interspersed with bitumen on newly-created tailings ponds. Vegetated islands sometimes contain small mammals and attract songbirds, both of which attract birds of prey. Waterbirds sometimes attempt to use these areas as nest sites.

Chapter 1

Origin of the project

On April 28, 2008, approximately 1,600 waterfowl landed on the Aurora Mine settling basin, which is managed by Syncrude Canada Limited, about 75 km north of Fort McMurray. At the time of the landing, air cannons were not fully deployed and, therefore, failed to deter birds from the open water of the basin, while most nearby water bodies remained frozen. As a result of becoming coated in residual bitumen floating on the water's surface, many of the birds that landed died.

Several months after the incident, the federal and provincial governments each laid charges against Syncrude.

- The Alberta government charged Syncrude with a violation of the province's Environmental Protection and Enhancement Act for failing to keep or store a hazardous substance in a manner that ensures that the hazardous substance does not directly or indirectly come into contact or contaminate any animals.
- The Federal Government charged Syncrude unlawfully deposited, or permitted the deposit of, a substance harmful to migratory birds in waters or an area frequented by birds, contrary to the Migratory Birds Convention Act.

The matter proceeded to trial and found Syncrude guilty on both charges.

With the Honourable Judge Ken Tjosvold presiding, the Court accepted a joint submission on sentencing, and on October 22, 2010, and in addition to fines, ordered Syncrude to fund:

- $1,300,000 for the research on the Avian Protection Project at the University of Alberta;
- $900,000 for the acquisition and conservation of a high value waterfowl habitat by a joint venture of environmental conservation organizations;
- $250,000 towards the development of avian-focused Wildlife Management Program at Keyano College, Ft. McMurray.

Project objectives

The court order identified four objectives for the portion of the order related to the research project, which are summarized below. The full order is available on the RAPP website (http://rapp.biology.ualberta.ca/).

1. Collect information on bird use and deterrence practices in the oil sands region and review avian deterrents in this and other industries;

2. Conduct field studies and supporting analyses;

3. Integrate with and support the development of a standardized monitoring program; and

4. Recommend best practices for bird protection by the mineable oil sands industry.

Duration

RAPP began on 1 November 2010 and was to have ended on 31 October 2013. On the advice of the Advisory Committee, I requested and received an extension to 30 April 2014. This extension made it possible to report on a third full season of the standardized monitoring program, which is described in Chapter 5.

RAPP Advisory Committee

The order also named a multi-stakeholder Advisory Committee comprised of the following individuals. Brief biographies for each can be found on the RAPP website (http://rapp.biology.ualberta.ca/). Tom Habib and Cindy McCallum provided technical support for the RAPP Advisory Committee.

- Colleen Cassady St. Clair (University of Alberta)
- John Gulley (Golder Associates Limited)
- Darrell Martindale (Shell Canada)
- Dave Fairless (Alberta Environment)
- Joel Ingram (Canadian Wildlife Service, Environment Canada)

Collaborators

Additional and extensive support for the third objective of the court order, to support a standardized monitoring program that had been announced by Alberta Environment in

September 2010 (Chapter 4), was provided by the following government ministries and industries.

- Alberta Environment (2010 – 2011)
- Alberta Environment and Water (2011)
- Alberta Sustainable Resource Development (2010 – 2012)
- Alberta Environment and Sustainable Resource Development (2012 – 2014)
- Canadian Wildlife Service, Environment Canada
- Canadian Natural Resources, Limited
- Imperial Oil, Canada, Limited
- Shell, Canada, Limited
- Suncor Energy, Inc.
- Syncrude Canada, Limited

Photos, Report and Website

Photos in this report were taken by members of the RAPP research team, unless otherwise indicated. A limited number of printed versions of this report will be available, but the entire report is contained on The RAPP website (http://rapp.biology.ualberta.ca/), which will be maintained as an archive in perpetuity on University of Alberta servers. It will also remain linked to my homepage while I remain a professor at the University of Alberta (http://www.biology.ualberta.ca/faculty/colleen_cassady_stclair/).

I welcome questions or comments about our work at any time: cstclair@ualberta.ca

The RAPP Advisory Committee was assisted in 2011 by Tom Habib (left) and consisted of (proceeding to right): Colleen Cassady St. Clair, Darrell Martindale, Joel Ingram, John Gulley, and Dave Fairless.

Background to the problem

The oil sands region of northern Alberta is estimated to contain the third largest oil reserve on Earth. The Government of Alberta estimates the oil sands deposit to underlie an area of 140 200 km^2, but only a small proportion of this deposit is accessible by surface mining. An estimated area of 715 km^2 is disturbed by current surface mines.

For the past 40 years, surface-accessible oil sands have been processed by excavating the sand from large, open-pit mines, separating the sand from the oil it contains using hot water, and depositing the by-products, including water, in tailings ponds. Water is typically recycled from the larger ponds for subsequent use in the mining process. In 2013, 64 ponds that contained process-affected water in the mineable oil sands region were identified as part of a standardized monitoring program. These ponds varied in both purpose and size from areas designed to collect surface drainage that were less than 1 ha in area to tailings ponds intended to capture liquid tailings from the mine in water bodies as large as 10 km^2.

The tailings ponds produced by the oil sands industry are hazardous to migratory waterbirds because fresh tailings contain several substances with known toxicity to wildlife, including bitumen, naphthenic acids, polycyclic aromatic hydrocarbons, heavy metals, and concentrated salts. Of these, bitumen poses a particular problem because even small amounts can coat feathers to impede flight, buoyancy, thermoregulation and foraging. Bitumen transferred from the feathers of a nesting bird to the surface of eggs is toxic to developing embryos.

Migrating waterbirds have high probabilities of encountering the tailings ponds produced by oil sands mining because this industrial activity begins just 150 km south of the Peace-Athabasca Delta, an internationally-important staging area for waterbirds that hosts as many as 1.5 million birds each spring and fall. As the second-largest freshwater delta in the world, the area is especially important to waterfowl and it is the only region in North America that is known to attract birds from all four of the continental flyways. During that travel, birds may stop to rest and seek forage or mates on tailings ponds, particularly when those ponds are ice-free in the early spring owing to warm water effluent, or during storm events in Spring or Fall that can cause migrating birds to land abruptly.

Oil sands operators employ a variety of techniques to deter birds from landing. Deterrents are typically comprised of auditory or visual stimuli, or a combination of the two, and are used in a variety of other industrial contexts, especially airports. As part of their environmental approvals, oil sands operators are obliged to create and submit a Waterfowl Protection Plan, which specifies how they will monitor the number of birds coming in contact with their tailings ponds and how they will endeavor to minimize those contacts. A minimum standard of action is implied by the concept of due diligence via legislation described by the provincial *Environmental Protection and Enhancement Act* and the federal *Migratory Birds Convention Act*. Neither piece of legislation provides specific guidelines to identify an acceptable number of birds that may be killed via contact with ponds or the appropriate type, intensity, and distribution of deterrents.

The need for bird protection in the oil sands engaged sudden public attention when 1600 birds died in the spring of 2008 at a tailings pond where deterrents had not yet been placed for the season. Ultimately, the absence of due diligence was fundamental to the subsequent conviction stemming from this event, but it did not obviously apply to the landing of over 500 birds in the fall of 2010 on six ponds containing process-affected water, all of which contained functioning deterrents. Both landing events highlighted the need for a standardized monitoring program that measures annually how many birds come in contact with process-affected water, how many die as a result of that contact, and how variation in landings and mortality are related to the specific deterrent practices that are applied to the dozens of ponds containing process-affected water. Only with specific and comparable information of this sort is it possible to identify rigorous and defensible standards for avian protection in this and other industrial contexts.

RAPP planning and reporting

From December 2010 through April 2011, the RAPP Advisory Committee met for 1.5 h approximately every two weeks by conference call to discuss RAPP research priorities and logistics. Detailed notes were taken from each meeting and circulated to the committee afterwards. From these discussions, we identified a set of research objectives that were contained in project summaries submitted to the Advisory Committee in December 2011 and December 2012. The committee met in person on three occasions in January of 2011 and 2012 and March of 2013. Periodic correspondence occurred via in-person meetings and via email and telephone with individual members of the advisory committee throughout the tenure of RAPP.

Many other individuals including collaborators, graduate students, and research assistants also contributed to RAPP planning, implementation, and management. In addition, new research opportunities arose, such as the government-invited analysis of the October 2010 landing event (Chapter 2). Consequently, the specific goals and objectives we outlined at the beginning of the project evolved considerably and much more attention than we originally intended was applied to the standardized monitoring program (Chapters 4 and 5). That investment was a necessary precursor for evaluating the performance of deterrent systems now and in the future. Advancing avian protection will require ongoing integration of robust monitoring with iterative changes in deterrent practices within a well-documented practice of adaptive management.

Many individuals contributed to the work done by RAPP, but three graduate students – Sarina Loots, Elizabeth Beck and Ffion Cassidy, led significant components of our research. They focused on automated detection of birds (Sarina), toxicology of process-affected water to waterfowl (Elizabeth) and the efficacy of visual deterrents (Ffion).

From left to right: Sarina Loots, Colleen Cassady St. Clair, Elizabeth Beck, and Ffion Cassidy. Each of Sarina, Elizabeth and Ffion will complete M.Sc. degrees this year via opportunities afforded by RAPP.

Bibliographic information

The literature that supports RAPP has grown over the years to approximately 2,000 documents. To keep this report manageable in size and to avoid redundancies, I have written chapter summaries with little or no use of the literature and, instead, contained it in the companion documents associated with each chapter. To facilitate use of our literature collections by others, individual members of the RAPP team have produced annotated bibliographies by topic (below). These lists are intended to provide a starting point to some of the key literature associated with each of the four topics that comprise our research work. Our website provides a full list of the literature we have consulted. Copyright laws prevent us from posting copies of articles on our website, but any individual who has difficulty obtaining an article of interest may contact us for assistance.

Historical and industry-based literature

Originally compiled by Rob Ronconi and refined by Julia Jackson

Blokpoel H, Burton J (1973) Weather and height of nocturnal migration in east central Alberta: a radar study. Bird Banding 46: 311-328.

Many bird species preferentially migrate at night. Determined the range in altitude of migrating birds using radar at Cold Lake, Alberta. Weather was found to drastically affect the altitude that birds fly at. Birds usually flew low if clouds were present. If no clouds were present, then birds flew at altitudes that offered ideal wind conditions.

Boag DA, Lewin V (1980) Effectiveness of three waterfowl deterrents on natural and polluted ponds. J Widlife Manag 44: 145-154.

Tested the effectiveness of three visual floating deterrent types for deterring birds from landing on small natural ponds. Out of the three deterrents tested, the human effigy was found to be the most effective.

Butterworth E, Leach A, Gendron M, Pollard B, and Stewart GR (2002) Peace-Athabasca Delta waterbird inventory program: 1998–2001 final report. Ducks Unlimited Canada. Edmonton, Alberta, Canada.

This report provides background on the Peace-Athabasca Delta, an important waterfowl area north of the Oil Sands region. Birds from all major migratory flyways in North America travel through Peace-Athabasca Delta. Threats to migratory waterfowl that visit the delta were evaluated, which included tailings ponds, industrial water use, and climate change.

Golder Associates Ltd (2000) Report on oil sands tailings pond bird deterrent systems-a review of research and current practices. Suncor Energy Inc., Syncrude Canada Ltd., and Albian Sands Energy Inc. Calgary. Alberta, Canada.

Bird deterrent systems have been in place on tailings ponds at Suncor Energy Inc. and Syncrude Canada Limited since 1976. Birds, including dabblers, divers, and waders, have been observed on and near tailings ponds where they can contact bitumen. Contact with bitumen for birds is typically fatal. At these sites, studies have been conducted to explore ways of minimizing bird contact with tailings ponds. This report assumes that migrating birds do not become habituated to deterrents in the Oil Sands.

Golder Associates Ltd (2009) The Suncor bird deterrent and monitoring program: History and evolution. Golder Associates Ltd. Report 09-1355-0004.

Historical bird deterrent systems and monitoring efforts at Suncor Energy Inc. are reported. Bird deterrent systems have changed over time, based on recommendations through research. Historically, visual deterrents were used, until 1981 when propane cannons were introduced, and then the Phoenix Wailer in 1993, which directionally projects sound. There is a discussion on the efficacy of radar-activated deterrents.

Gulley J (1980) Factors influencing the efficacy of human effigies in deterring waterfowl from polluted ponds. Master of Science, University of Alberta, Edmonton, Canada.

The effectiveness of human effigy bird deterrents on tailings ponds were studied in this thesis. Some critical factors were identified that affect the number of landed birds, which were: 1) number of migratory birds in region, 2) distance to freshwater, 3) timing of ice-breakup of fresh waterbodies, 4) average spring temperature, and 5) precipitation. Human effigies were not effective at deterring shorebirds.

Hennan EG, Munson B (1979) Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta, LS 22.1.2 Canadian Wildlife Service: Edmonton, Alberta, Canada.

Observed the abundance and diversity of waterfowl in the Oil Sands region. Additionally, the habitat preferred by dabblers and divers was determined. Birds from all major migratory flyways in North America were observed. The majority of these migrants travel through the Oil Sands region to reach the Peace-Athabasca Delta, an important staging ground for waterfowl. The Oil Sands region itself is not an important staging ground for migratory waterfowl.

Ronconi RA (2006) Predicting bird oiling events at oil sands tailings ponds and assessing the importance of alternate water bodies for waterfowl: a preliminary assessment. Can Field Nat 120: 1-9.

Compared waterfowl activity at tailings ponds and natural ponds during spring migration in the Oil Sands region. Waterfowl were observed to use tailings ponds over natural ponds during time period when tailings ponds had thawed but natural ponds had not. High precipitation levels increase the risk of birds becoming oiled.

Ronconi RA, St. Clair CC (2006) Efficacy of a radar-activated on-demand system for deterring waterfowl from oil sands tailings ponds. J Appl Ecol 43: 111–119.

Deterrents in the Oil Sands region used to deter birds from landing on tailings ponds can be ineffective. Birds that landed at tailings ponds were recorded while testing deterrents using three treatments. The three treatments were radar-activated on-demand deterrents, random-fire deterrents, and no deterrents (control). The radar-activated on-demand deterrent treatment was the most effective at deterring birds, especially shorebirds. Different stimuli of deterrents were also tested. Cannons were found to be more effective at deterring birds than human effigies.

Schick CD, Ambrock DR (1974) Waterfowl investigations in the Athabasca tar sands area. Canadian Wildlife Service: Canada.

Birds from all the major migratory flyways in North America travel through Peace-Athabasca Delta, located north of the Oil Sands region. The threat of tailings pond development on migratory birds flying through the Oil Sands region is recognized in this report. Threats on waterfowl due to the development of this region were rated by the potential magnitude of their impact. The greatest threats to waterfowl were identified as composition and temperature of liquid tailings, oil spills, and fresh water demand. This report suggested that bird deterrents be placed near tailings ponds to deter birds from landing.

Soper, JD (1951) Waterfowl and related investigations in the Peace-Athabasca Delta region of Alberta. Canadian Wildlife Service: Wildlife Management, Ottawa, Ontario, Canada.

Conducted waterfowl surveys in the Peace-Athabasca Delta. Includes details of surveys performed at particular locations, and the abundance, time period, and location of individual duck species in the area. Vegetation present within the delta, and average monthly temperatures are also noted.

St. Clair CC, Ronconi RA (2009) Review of Alberta Environment 2009 compliance inspection reports and avian deterrence in the oil sands region. Prepared for Alberta Environment. 36 pp.

Reviewed operator inspection reports and pond inventories, and identified gaps in knowledge for avian deterrents. Six recommendations were made to improve avian deterrence in the Oil Sands region, including the development of a standardized bird monitoring protocol and a tested standardized level of deterrents used across sites.

Timoney KP, Ronconi RA (2010) Annual bird mortality in the bitumen tailings ponds in northeastern Alberta, Canada. Wilson J Ornithol 122: 569-576.

Evaluated three datasets for annual bird mortalities caused by tailings ponds in the Oil Sands region. Industry data appeared to underestimate the number of bird mortalities when compared to scientific data. The scientific data was based on a number of mortalities at Albian Sands Muskeg River Mine that was extrapolated based on the total area that tailings ponds cover in the Oil Sands region.

Van Meer T, Arner B (1985) Bird surveillance and protection programme, summary of 1984 and 1985 activities. Syncrude Canada Ltd, Calgary, Alberta, Canada.

Results provided from monitoring and mortality data collected in 1984 and 1985 from the Mildred Lake lease site of Syncrude Canada Limited. Waterfowl make up a larger percentage of birds recorded in the monitoring data than in the mortality data. For shorebirds, this trend is reversed.

Yonge KS (1979) Development of a bird protection strategy for tar sands tailings ponds. Proceedings of the 8th Bird Control Seminar, Bowling Green, Ohio, Oct.

The greatest risk of birds making contact with tailings ponds occurs when warm effluent causes tailings ponds to undergo spring ice breakup prior to natural ponds. Methods that prevent birds from becoming oiled by the Syncrude Canada Limited tailings ponds were identified. These methods were: 1) reducing habitat attractiveness, 2) containing oil, 3) deterring birds from landing, and 4) rehabilitating oiled birds. Recommended standardized bird monitoring program, and that deterrents should be operational in early spring prior to migration.

Yonge KS, Christiansen ML (1979) A review of bird migration patterns and techniques for monitoring migration. Professional Paper 1981-2. Syncrude Canada Ltd, Calgary, Alberta, Canada.

The objectives of this report were to identify factors that affect the number of birds migrating through an area, and conditions that cause migrating birds to land. Factors that cause birds to land on tailings ponds in the Oil Sands region can be potentially fatal if they become oiled. Literature was reviewed to provide insight on their objectives.

Avian Deterrents

Compiled by Ffion Cassidy

Ackerman JT, Eadie JM, Moore TG (2006) Does life history predict risk-taking behavior of wintering dabbling ducks? Condor 108: 530–546.

Examines the effect of life-history strategy on anti-predator behaviour of dabbling ducks. Species which live longer and produce fewer offspring are more risk-averse than those which have shorter lifespans and are more fecund.

Andelt WF, Woolley TP, Hopper SN (1997) Effectiveness of barriers, pyrotechnics, flashing lights, and Scarey Man for deterring heron predation on fish. Wildl Soc Bull 25: 686-694.

Pyrotechnics are effective, but flashing lights, and Scarey Man effigies are ineffective in deterring heron predation on trout. Periods where pyrotechnics are not employed should be part of a management strategy to prevent habituation.

Blackwell BF, Bernhardt GE, Dolbeer RA (2002) Lasers as nonlethal avian repellents. J Widlife Manag 66: 250–258.

Lasers tested for bird avoidance and dispersal effects in waterfowl and others. Choice experiments of grass plot (geese and ducks) and perches (starlings, brown headed cowbirds, rock doves). Geese showed marked avoidance of laser-treated plots. Mallards showed initial deterrence from laser-treated grass plots, but habituated after 20 minutes. Lasers did not have an effect on perch choice for European starlings or brown headed cowbirds. Rock doves were initially deterred but quickly habituated.

Bomford M, O'Brien PH (1990) Sonic deterrents in animal damage control: a review of device tests and effectiveness. Wildlife Soc B: 411–422.

Comprehensive review of sonic deterrents for multiple species. Mixed evidence for birds – some accounts of gulls and geese being repelled by alarm calls, and some accounts of biosonic devices having no effect in the field. Responses to non-biological relevant novel stimuli are also variable.

Boag DA, Lewin V (1980) Effectiveness of three waterfowl deterrents on natural and polluted ponds. J Widlife Manag 44: 145-154.

Three types of visual deterrent (falcon model, moving reflectors, human effigy) were tested to determine their efficacy in deterring waterfowl from natural ponds and industrial tailings ponds. Only the human effigy was effective, especially for diving ducks. Yearly mortality on tailings ponds was lower in the year when effigies were deployed than in the preceding year when there were no effigies, after correcting for relative abundance.

Conover MR (2010) Fear Provoking Stimuli. In: Resolving human-wildlife conflicts: the science of wildlife damage management. Boca Raton: CRC press. Pp 229-247.

Comprehensive review of wildlife deterrents, divided by sensory modality. Many references to peer-reviewed deterrent research, as well as pros, cons, and anecdotal information.

Gulley J (1980) Factors influencing the efficacy of human effigies in deterring waterfowl from polluted ponds. Master of Science, University of Alberta, Edmonton, Canada.

The efficacy of human effigies as visual deterrents was tested on a tailings pond over a two year period. A rotating light becon was added to the effigies in the second year to facilitate bird detection of the effigies at night. Annual waterfowl deaths, corrected for relative abundance, were used to assess efficacy. The effigies appeared to be effective in deterring birds, but other factors such as temperature and precipitation were important to bird mortalities.

Harris RE, Davis RA (1998) Evaluation of the efficacy of products and techniques for airport bird control. LGL Limited Environmental Research Associates, King City, Ontario, Canada. TP 13029.

Good review of available deterrent techniques. Many methods and modalities discussed. Includes references to peer-reviewed scientific literature.

Lehoux D, Bordage D (2000) Deterrent Techniques and Bird Dispersal Approach for Oil Spills. Environment Canada, Canadian Wildlife Service. Pp 1-80.

Deterrent review aimed at bird protection from oil spills, but many relevant techniques for tailings ponds. Divided by deterrent type, and includes references to peer reviewed studies.

Lecker CA, Parsons MH (2013) Mixed modalities: Using bioacoustics and optical cues to influence behavior of Ring-billed Gulls (*Larus delawarensis*) in Rouses Point, NY. J Veterinar Sci Technolo 4:4.

Experiment testing the response of ring-billed gulls to lasers in the presence and absence of two colours of lasers. Gull response was measured by repellence from a roost, time to flight, and flight distance. Gulls responded more when signals were combined than when signals were presented alone. Habituation was not observed, and response to signals presented alone increased over the duration of the trial.

Marsh RE, Erickson WA, Salmon TP (1992) Scarecrows and predator models for frightening birds from specific areas. Proc. 15th Vertebrate Pest Conf. 112-114

Good review of available visual deterrent devices. Contains references to some controlled studies on efficacy.

Read JL (1999) A strategy for minimizing waterfowl deaths on toxic waterbodies. J Appl Ecol, 36, 345-350.

Experiment testing deterrent efficacy in preventing landings on toxic industrial ponds. An intermittent, rotating beam of light was shone from a beacon across the pond surface. The deterrent caused a 90% reduction of duck landings on the pond. Waders were not affected by the deterrent. Grebes were not deterred from the pond when the deterrent was activated because they tended to dive to escape the spotlight. Monthly rates of bird deaths on the pond have decreased since the installation of the deterrent system

Ronconi RA, St Clair CC (2006) Efficacy of a radar-activated on-demand system for deterring waterfowl from oil sands tailings ponds. J Appl Ecol 43: 111–119.

Study testing the effect of on-demand deterrents, randomly activated deterrents, and no deterrents on the numbers of birds landing on a tailings pond. On-demand deterrents were most effective, presumably because of reduced habituation. Birds responded more to propane cannons than peregrine sounds and effigies. Bird guild impacted bird response to deterrents.

Seamans TW, Bernhardt GE (2004) Response of Canada geese to a dead goose effigy. USDA National Wildlife Research Center - Staff Publications. Paper 384.

Field trials were conducted to determine if post-fledging flocks of Canada geese were deterred by a dead goose effigy. There were significantly fewer geese observed when the effigy was placed during the first set of trials. No similar effect was seen in territorial pairs. The geese habituated to the effigy after a period of several days.

Soldatini C, Albores-Barajas YV, Torricelli P, Mainardi D (2008) Testing the efficacy of deterring systems in two gull species. Applied Anim Behav Science 110: 330–340.

Three scaring methods (visual, acoustic, falconry) were tested on two species of gull at a landfill. An index was developed to measure habituation. The methods employed were effective for a short time only, after which habituation occurred.

Spanier E (1980) The use of distress calls to repel night herons (*Nycticorax nycticorax*) from fish ponds. J Appl Ecol: 287–294.

Distress calls of young and adult night herons were tested for their effect on night heron predation of trout ponds. Over 80% of herons were repelled from ponds when distress calls of their own species were played. No habituation was observed over a period of several weeks.

Stevens GR, Rogue J, Weber R, Clark L (2000) Evaluation of a radar-activated, demand-performance bird hazing system. Int Biodeterior Biodegradation 45: 129–137.

A radar-activated bird hazing system was tested for its effectiveness in deterring waterfowl. Deterrents included in the system were acoustic alarm calls, pyrotechnics, and chemical, tear-gas-like repellents. Birds were 12.5 times less likely to fly over the hazed pond, and 4.2 times less likely to land as compared to an unprotected control pond. No habituation to the on-demand system was observed. Yearly mortality was 6.5 times lower compared to years when the hazing system was not in place.

Werner SJ, Clark L (2006) Effectiveness of a motion-activated laser hazing system for repelling captive Canada geese. Wildlife Soc B 34:2–7.

Experiment testing the effectiveness of a motion-activated laser hazing system in repelling captive Canada Geese from grassy plots. Geese avoided treated subplots, and the conditioned aversive response remained for up to 2 days post-treatments.

Toxicology of process-affected water

Compiled by Elizabeth Beck

Albers PH (2006) Birds and polycyclic aromatic hydrocarbons. Avian Poultry Biol Rev 17: 125–140.

A review of the toxic effects of polycyclic aromatic hydrocarbons (PAH) on birds.

Albers PH (2007) An Annotated Bibliography on Petroleum Pollution. Version 2007. USGS Patuxent Wildlife Research Center, Laurel, MD, U.S.A.

Collection of literature on petroleum as an environmental contaminant. Covers all taxa, primarily focused on conventional oils, and following marine oil spills.

Allen EW (2008) Process water treatment in Canada's oil sands industry: I. Target pollutants and treatment objectives. J Environ Eng Sci 7: 123–138.

A review of the Alberta oil sands and use of tailings ponds. Focused on issues with tailings pond water quality and toxicity. Identified target pollutants, wet landscape reclamation options, and water treatment objectives.

Cruz-Martinez L, Smits JEG (2012) Potential to use animals as monitors of ecosystem health in the oil sands region. Report No. TR-18; OSRIN: University of Alberta, Edmonton, Alberta, Canada.

A review of the effects of contaminants on wildlife and the potential to use them as indicators of environmental and human health. Focused on aquatic toxicology, and identified gaps in studies on airborne contaminants. Descriptions of the oils sands and contaminants of concern, and examples of their toxic effects to a range of organisms.

Dagenais L (2008) Effects of oil sands extraction activities on breeding birds in the Athabasca oil sands region. Master of Science, University of Alberta, Edmonton, Alberta, Canada.

Examined the effects of oil sands reclaimed habitats on wetland and terrestrial bird communities. Did not find evidence that bird guild abundances were negatively affected, some guilds were positively affected. Historical data suggests that on one of the lease sites there was a decreased in species richness from earlier sampling years, and significantly different community composition.

Eisler R (1987) Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates. A Synoptic Review. Biological Report 85 (1.11); U.S. Fish and Wildlife Service: Laurel, MD, U.S.A.

A synthesis of the literature on the ecology and toxicology of PAHs in the environment. Descriptions of the sources, fates and chemical properties of PAHs, as well as background concentrations in the environment and biological samples. Descriptions of the toxicities of PAHs to different flora and fauna.

Gentes M-L, McNabb A, Waldner C, Smits JEG (2007) Increased thyroid hormone levels in tree swallows (*Tachycineta bicolor*) on reclaimed wetlands of the Athabasca oil sands. Arch Environ Contam Toxicol 53: 287–92.

Examined the endocrine disrupting effect of reclaimed wetlands on tree swallow thyroid function. Found higher levels of circulating T3, and higher T4 in the thyroid gland which suggests increased synthesis, and decreased conversion of T4 into T3. Changes to thyroid function can affect body systems such as those involved in metabolism, behavior, and feather development, which can compromise survival post-fledging.

Gentes M-L, Waldner C, Papp Z, Smits JEG (2006) Effects of oil sands tailings compounds and harsh weather on mortality rates, growth and detoxification efforts in nestling tree swallows (*Tachycineta bicolor*). Environ Pollut 142: 24–33.

Examined viability of oil sands experimental wetlands using tree swallows. Examined reproductive success, nestling growth, survival, and EROD activity across two breeding seasons. Found higher mortality 2003 associated with extreme weather, and low mortality 2004 but smaller body weights and higher EROD. Conclude treatment birds may be compromised, which could decrease post-fledging survival.

Gentes M-L, Waldner C, Papp Z, Smits JEG (2007) Effects of exposure to naphthenic acids in tree swallows (Tachycineta bicolor) on the Athabasca oil sands, Alberta, Canada. J Toxicol Environ Health A 70: 1182–90.

Examined the effects of naphthenic acids on tree swallows nesting on oil sands wetlands. Found no effect on nestling growth, PCV, biochemistry, organ weights, or EROD. Found increased extramedullary erythropoiesis in the liver. Conclude nestlings can tolerate short-term exposure, but potential effects may extend to chronic and reproductive toxicities later in life.

Gentes M-L, Whitworth TL, Waldner C, Fenton H, Smits JE (2007) Tree swallows (*Tachycineta bicolor*) nesting on wetlands impacted by oil sands mining are highly parasitized by the bird blow fly *Protocalliphora spp*. J Wildl Dis 43: 167–178.

Examined viability of oil sands experimental wetlands using tree swallows. Found that bird nests on reclaimed wetlands had 60-72% more blow fly larvae than those on reference sites. Nestlings had twice the parasite burden and decreased mass than nestlings on reference sites. Conclude that OSPM wetlands have altered functions, which include changes to habitat characteristics and host resistance to parasites.

Gurney KE, Williams TD, Smits JE, Wayland M, Trudeau S, Bendell-Young LI (2005) Impact of oil-sands based wetlands on the growth of mallard (*Anas platyrhynchos*) ducklings. Environ Toxicol Chem 24: 457–463.

Examined the effects of oil sands wetlands on waterfowl population using mallard ducklings. Examined duckling mass, skeletal size, and plasma metabolites (triglycerides and glycerol; indicators of physiological condition), PAH metabolites, and EROD. Found decreased mass and size, which could affect survival later in life. Found no effect on EROD, but evidence of higher PAHs (via bile metabolites).

Gosselin P, Hrudey SE, Naeth M, Plourde A, Therrien R, Van Der Kraak G, Xu Z (2010) Environmental and health impacts of Canada's oil sands industry; Royal Society of Canada Expert Panel: Ottawa, Ontario, Canada.

Reviews primarily focused on the environmental and health impacts of the oil sands. Cover the effects of contaminants on environmental, human, and wildlife health. Discuss regional water, groundwater, and air quality issues. Review oil sands technologies, tailings ponds, and reclamation processes. Also, discuss the financial, social, and political aspects of the oil sands.

Harms NJ, Fairhurst GD, Bortolotti GR, Smits JEG (2010) Variation in immune function, body condition, and feather corticosterone in nestling tree swallows (*Tachycineta bicolor*) on reclaimed wetlands in the Athabasca oil sands, Alberta, Canada. Environ Pollut 158: 841–8.

Examined viability of oil sands experimental wetlands using tree swallows. Found that nestlings on some of the OSPM wetlands were heavier, with longer wing lengths, and had a stronger immune response (delayed-type hypersensitivity (DTH)). Found no effect on reproductive parameters. No overall difference in corticosterone, but corticosterone was higher in males on one of two OSPM wetlands as compared to the reference site. They conclude that with ideal environmental conditions these wetlands can support viable populations.

Hebert CE, Weseloh DVC, Macmillan S, Campbell D, Nordstrom W (2011) Metals and polycyclic aromatic hydrocarbons in colonial waterbird eggs from Lake Athabasca and the Peace-Athabasca Delta, Canada. Environ Toxicol Chem 30: 1178–83.

Hebert CE, Campbell D, Kindopp R, MacMillan S, Martin P, Neugebauer E, Patterson L, Shatford J (2013) Mercury trends in colonial waterbird eggs downstream of the oil sands region of Alberta, Canada. Environ Sci Technol 47: 11785–92.

Examined metal and PAH trends in the eggs of waterbirds nesting downstream of the oil sands. Found that the mercury burdens in the eggs of California and Ring-billed gulls have increased since earlier sampling dates (1977 and 2009 respectively). Mercury was also correlated with NA concentrations, which may suggest a common source for these substances. They suggest this might be in part because the diet of these birds primarily consists of fish, which respond quickly to fluctuating environmental mercury levels (Hebert et al., 2013). Although they did not describe any toxic effects at the levels observed, further accumulation could be harmful because of the biomagnification of mercury in food webs.

Kelly EN, Schindler DW, Hodson PV, Short JW, Radmanovich R, Nielsen CC (2010) Oil sands development contributes elements toxic at low concentrations to the Athabasca River and its tributaries. PNAS 107: 16178–16183.

Tested for oil sands contaminants in the Athabasca River and tributaries. Found 13 elements considered priority pollutants in either water or snowpack samples. Only seven of these elements exceeded water quality guidelines for the protection of aquatic life.

Kelly EN, Short JW, Schindler DW, Hodson PV, Ma M, Kwan AK, Fortin BL (2009) Oil sands development contributes polycyclic aromatic compounds to the Athabasca River and its tributaries. PNAS 106: 22346–22351.

Measured deposition of polycyclic aromatic compounds (PAC) in water and snowpack surrounding oil sands upgrading facilities. Found high deposition of airborne particulates, especially PACs in snowpack, as well as high dissolved PACs. Also found increases in dissolved PACs in the Athabasca river. PACs were higher downstream of development when compared to upstream. This was more apparent in summer than winter.

King JR, Bendell-Young LI (2000) Toxicological significance of grit replacement times for juvenile mallards. J Wildl Manage 64: 858–862.

Ingestion of grit (OSPM) is also a significant route of contaminant exposure, at least for mallards, particularly for compounds such as oil and grease

Leighton FA (1993) The toxicity of petroleum oil to birds. Environ Rev 1: 92–103.

A general literature review of various effects of petroleum oils to birds. Described typical routes of exposures, and the pathologies associated with contact. Focused on conventional crude and fuel oils. No information on the effects of the oil sands.

Smits JE, Wayland ME, Miller MJ, Liber K, Trudeau S (2000) Reproductive, immune, and physiological end points in tree swallows on reclaimed oil sands mine sites. Environ Toxicol Chem 19: 2951–2960.

Examined viability of oil sands experimental wetlands using tree swallows. Found no differences in reproductive success, growth, or immune responses. Found increased EROD.

Monitoring biodiversity

Compiled by Aditya Gangadharan

Buckland ST, Handel C (2006) Point-transect surveys for songbirds: robust methodologies. Auk 123: 345–357.

Robust field methods and theory of bird point transect surveys.

Burke C, Montevecchi W, Wiese FO (2012) Inadequate environmental monitoring around offshore oil and gas platforms on the Grand Bank of Eastern Canada: are risks to marine birds known? J Environ Manage 104: 121-126.

On the requirement for comprehensive environmental monitoring around oil rigs.

Cox MJ, Borchers DL, Kelly N (2013) nupoint: An R package for density estimation from point transects in the presence of nonuniform animal density. Methods Ecol Evol.

Model and software to estimate density from point transects when abundance is non-uniform.

Dorazio RM, Royle JA, Söderström B, Glimskär A (2006) Estimating species richness and accumulation by modeling species occurrence and detectability. Ecology 87: 842–854.

Models to estimate detection probability, occupancy and species richness.

Elzinga CL, Salzer DW, Willoughby JW, Gibbs JP (2001) Monitoring plant and animal populations. Blackwell Science, Oxford, UK.

General reference on monitoring.

Garrard GE, McCarthy MA, Williams NS, Bekessy SA, Wintle BA (2013) A general model of detectability using species traits. Methods Ecol Evol 4: 45–52.
A framework for incorporating differing species detectability into population estimates.

Graves TA, Royle JA, Kendall KC, Beier P, Stetz JB, et al. (2012) Balancing precision and risk: should multiple detection methods be analyzed separately in N-mixture models? PloS one 7: e49410.

Estimating population parameters using data collected through different methods.

Kery M, Royle JA, Schmid H, Schaub M, Volet B, et al. (2010) Site-Occupancy Distribution Modeling to Correct Population-Trend Estimates Derived from Opportunistic Observations. Conserv Biol 24: 1388–1397.

Models for opportunistic data.

MacKenzie DI (2006) Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington, USA.

Comprehensive reference on estimating occupancy while incorporating detection probability.

MacKenzie DI, Royle JA (2005) Designing occupancy studies: general advice and allocating survey effort. J Appl Ecol 42: 1105–1114.

Planning monitoring protocols.

Marques TA, Thomas L, Fancy SG, Buckland ST, Handel C (2007) Improving estimates of bird density using multiple-covariate distance sampling. Auk 124: 1229–1243.

The incorporation of detection covariates into distance sampling estimates.

Marques TA, Buckland ST, Bispo R, Howland B (2013) Accounting for animal density gradients using independent information in distance sampling surveys. Stat Methods Appl: 1–14.

Estimating population sizes when there is a density gradient in animal distribution.

Mccarthy KP, Rota CT, Hutto RL, et al. (2012) Predicting species distributions from samples collected along roadsides. Conserv Biol 26: 68–77.

Models for species distributions from non-random survey data.

McDonald-Madden E, Baxter PW, Fuller RA, Martin TG, Game ET, et al. (2010) Monitoring does not always count. Trends Ecol Evol 25: 547–550.

How much and when to invest in monitoring biodiversity.

Norvell RE, Howe FP, Parrish JR, Thompson III F (2003) A seven-year comparison of relative-abundance and distance-sampling methods. Auk 120: 1013–1028.

Evaluating the effects of not incorporating detection probability on bird population trends.

O'Hara PD, Morgan KH (2006) Do low rates of oiled carcass recovery in beached birds indicate low rates of ship-source oil spills? Marine Ornith 34: 133-140.

Cautions on the interpretation of beached birds as an estimate of actual oil spills.

Sauer JR, Blank PJ, Zipkin EF, Fallon JE, Fallon FW (2013) Using multi-species occupancy models in structured decision making on managed lands. J Wildl Manage 77: 117–127.

Maximizing multi-species occupancy while incorporating management requirements.

Thompson W (2004) Sampling rare or elusive species: concepts, designs, and techniques for estimating population parameters. Island Press.

General principles of sampling rare species.

Yoccoz NG, Nichols JD, Boulinier T (2001) Monitoring of biological diversity in space and time. Trends Ecol Evol 16: 446–453.

Design of the principles and applications of monitoring programs.

Bird detection via marine radar

Compiled by Sarina Loots

Beason R, Nohara TJ, Weber P (2013) Beware the Boojum: caveats and strengths of avian radar. Hum-Wildl Ints 7: 16–46.

One of the more applicable critiques of marine radar for the use of bird detection at industrial applications.

Burger AE (1997) Behavior and numbers of Marbled Murrelets measured with radar. J Field Ornithol: 208–223.

Radar ground-truth study in which marbled murrelets were the only targets, as confirmed by flight patterns and human observations. Study found that radar was more effective than human observers (which had been the marrbled murrelet survey standard to date) because murrelets were very active a half hour before and after sunrise and did not call during those flights, making them undetectable by humans through either sight or sound

Chen W, Ning H, Li J (2011) Flying Bird Detection and Hazard Assessment for Avian Radar System. J. Aerospace Eng. 25: 246–255.

The authors use Merlin's radar system at an airport in China and develop radar processing software.

Cooper BA, Day RH, Ritchie RJ, Cranor CL (1991) An improved marine radar system for studies of bird migration. J Field Ornithol: 367–377.

One of the first studies to mobilize marine radar on trailers to monitor marine birds.

Dokter AM, Baptist MJ, Ens BJ, Krijgsveld KL, van Loon EE (2013) Bird radar validation in the field by time-referencing line-transect surveys. PloS one 8: e74129.

The only peer-review radar study that evaluates diurnal radar detection compared to human observers.

Eastwood E (1967) Radar Techniques for Detection, Tracking and Navigation. Nature 213: 1072.

One of the first radar articles, cited by most subsequent radar publications.

Gauthreaux (2003) Radar Ornithology and Biological Conservation. Auk 120: 266–277.

Overview of radar used for bird studies; largely discusses marine and weather radar.

Hilgerloh G, Caprano T, Griebeler EM (2010) Calibrating the Operational Beam Width and Maximum Range of a Ship Radar Used for Bird Observations. J Navigation 63: 363–371.

Test and discussion of the actual versus the expected radar beam.

Larkin RP (2005) Radar techniques for wildlife biology. Techniques for wildlife investigations and management. Bethesda, MD.

Overview of radar for bird detection. Book chapter in wildlife techniques book published by TWS.

Liechti F, Bruderer B, Paproth H (1995) Quantification of nocturnal bird migration by moonwatching: comparison with radar and infrared observations. J Field Ornithol 66: 457–468.

Radar ground-truth study comparing proportions of bird migration by radar with other nocturnal monitoring methods.

Nohara TJ, Beason RC, Weber P (2012) The role of radar-activated waterfowl deterrents on tailings ponds. International Oil Sands Tailings Conference.

A conference proceedings article that describes radar in the context of the oil sands

Peckford ML, Taylor PD (2008) Within night correlations between radar and ground counts of migrating songbirds. J Field Ornithol 79: 207–214.

Radar ground-truthing study relating proportions of nocturnal radar detections to diurnal surveys by conventional human-observer techniques.

Ronconi RA, St Clair CC (2006) Efficacy of a radar-activated on-demand system for deterring waterfowl from oil sands tailings ponds. J Appl Ecol 43: 111–119.

A peer-reviewed article describing the use of marine radar to detect and deter birds the oil sands; the primary focus is the efficacy of bird-triggered deployment of deterrents in comparison to cannons firing continuously at random intervals.

Schmaljohann H, Liechti F, Bächler E, Steuri T, Bruderer B (2008) Quantification of bird migration by radar-a detection probability problem. Ibis 150: 342–355.

Discusses some of the attributes that influence radar survey volume and its impacts on migration quantification from radar detection of nocturnal migration.

Stevens GR, Rogue J, Weber R, Clark L (2000) Evaluation of a radar-activated, demand-performance bird hazing system. Int biodeter & biodegr 45: 129–137.

This article tests the same radar-activated bird deterrent system that Ronconi & St Clair (2006) tested in 2003 at Shell at an industrial waste pond. No control pond.

Taylor P, Brzustowski J, Matkovich C, Peckford M, Wilson D (2010) radR: an open-source platform for acquiring and analysing data on biological targets observed by surveillance radar. BMC Ecol 10: 22.

Describes the open-source radar program developed by RAPP collaborators and used in the RAPP radar field research.

Williams TC, Williams JM, Kloeckner PD (1986) Airspeed and heading of autumnal migrants over Hawaii. Auk 103: 634–635.

The authors used both an L-band radar at high elevation (1200m) and an S-band radar at sea level. They do note that their radar at high elevation did not detect anything (even small birds) below its radar beam, below 1200m

Williams TC, Williams JM, Williams PG, Stokstad P (2001) Bird migration through a mountain pass studied with high resolution radar, ceilometers, and census. Auk 118: 389–403.

Radar ground-truth study comparing proportions of bird migration by radar with other nocturnal monitoring methods. This article discusses nocturnal migration in terms of the obstacles to overcome/avoid/not en route and the contrast between NA migrants (who don't avoid mountains, etc) vs European migrants

Use of Cameras for Monitoring

Compiled by Sarina Loots

Bajzak D, Piatt JF (1990) Computer-aided procedure for counting waterfowl on aerial photographs. Wildlife Soc B 18: 125–129.

Automated processing of aerial bird monitoring

Bardeli R, Wolff D, Kurth F, Koch M, Tauchert K-H, et al. (2010) Detecting bird sounds in a complex acoustic environment and application to bioacoustic monitoring. Pattern Recogn Lett 31: 1524–1534.

Automated processing of acoustic bird monitoring

Burke C, Montevecchi W, Wiese F (2012) Inadequate environmental monitoring around offshore oil and gas platforms on the Grand Bank of Eastern Canada: Are risks to marine birds known? J Environ Manage 104: 121–126.

Highlights the need for enforced, standardized bird monitoring techniques at offshore oil and gas platforms.

Flickinger EL, Bunck CM (1987) Number of oil-killed birds and fate of bird carcasses at crude oil pits in Texas. Southwest Nat 32: 377–381.

Mortality search study using manual surveys of oil pits (small waste water ponds) to evaluate decomposition rates of different bird guilds. Potential camera monitoring application.

Groom G, Stjernholm M, Nielsen RD, Fleetwood A, Petersen IK (2012) Remote sensing image data and automated analysis to describe marine bird distributions and abundances. Ecol Inform. 14: 2-8.

Automated aerial photo processing with discussion of aircraft versus satellite gathered photos.

Hamel S, Killengreen ST, Henden J-A, Eide NE, Roed-Eriksen L, et al. (2012) Towards good practice guidance in using camera-traps in ecology: influence of sampling design on validity of ecological inferences. Method Ecol Evol. 4: 105-113.

Comparison of two settings of conventional wildlife cameras: time-interval with sensor-triggered; very different results on the same targets with the two camera settings.

Harris G, Thompson R, Childs JL, Sanderson JG (2010) Automatic storage and analysis of camera trap data. Bull Ecol Soc Amer 91: 352–360.

Open-source software used to label, file, and extract metadata from large collection of field-gathered wildlife camera photos. No automated processing.

Hutto RL, Stutzman RJ (2009) Humans versus autonomous recording units: a comparison of point-count results. J Field Ornithol 80: 387–398.

Automated monitoring technique for acoustic bird monitoring using recorders compared with humans observers.

Kross SM, Nelson XJ (2011) A portable low-cost remote videography system for monitoring wildlife. Method Ecol Evol 2: 191–196.

Video camera recording set up designed for monitoring nest predation.

O'Connell AF, Nichols JD, Karanth KU (2011) Camera traps in animal ecology: methods and analyses. Springer Tokyo.

Overview of camera traps with information on sensor-activated ground-dwelling forest birds and bird nest camera monitoring.

Santos CD, Lourenço PM, Miranda AC, Granadeiro JP, Palmeirim JM (2008) Birds after dark: an efficient and inexpensive system for making long-range observations at night. J Field Ornithol 79: 329–335.

Infra-red illumination of shorebirds foraging at night within around 200 m, recorded by video to incorporate IR illumiation.

Shakeri M, Zhang H (2012) Real-Time Bird Detection Based on Background Subtraction. Proceedings of the 10th World Congress on Intelligent Control and Automation.

Description of the bird motion detection code developed by collaborators and used in the RAPP automated camera photo processing.

Trathan PN (2004) Image analysis of color aerial photography to estimate penguin population size. Wildlife Soc B 32: 332–343.

An American Coot in a reed bed. Photo by Dave Fairless.

Chapter 2: Report to Alberta Environment on the October Landing Event

On 25 October, 2010, just 3 days after the creative sentence in *R. v Syncrude* had been announced, another landing event occurred that resulted in the mortality of several hundred birds. Early in 2011, I was invited by Alberta Environment to examine the characteristics of process-affected water ponds associated with the event and to determine whether increased deterrent density might have prevented the mortalities.

The full report can be found on the RAPP website (http://rapp.biology.ualberta.ca/). The title, authors, and executive summary of the *Report to Alberta Environment on the October 2010 Landing Event* are reproduced below. The report is being converted to a peer-reviewed publication with additional information and analyses.

An offshore-drilling platform in The Netherlands has reported that green light reduces the number of seabirds that circle the station. Photo from Poot *et al*. 2008

Spatial and temporal correlates of mass bird mortality in oil sands tailings ponds

A report prepared for Alberta Environment by

Colleen Cassady St. Clair, Thomas Habib, and Bryon Shore, 10 November 2011

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Executive Summary

On October 25 and 26, 2010, 547 dead birds were recovered and recorded by operators in the oil sands region of Alberta. These deaths exceeded the occasional mortalities that are reported by operators in a typical year and resulted in an investigation by Alberta Environment. As part of that investigation, Cory McLaughlin, an investigating officer with Alberta Environment, asked me to address the questions that follow. More information on the context of that request and subsequent discussions is included in the cover letter to Cory that accompanies this report. I address each of the questions below and conclude each with a set of conclusions. I provide additional synthetic conclusions and recommendations at the end of the report. Three appendices follow the report detailing weather and GIS information. Answers to my questions include several additional tables and figures that are referenced within the text.

The main conclusions of my analyses are as follows:

1. Adverse weather conditions undoubtedly contributed to the recoveries recorded on October 25 and 26, 2010. Adverse conditions included strong and variable winds, precipitation, dense cloud cover, and darkness. There is no evidence that the recovered birds were in ill health, but the positions of deterrents and artificial lights may have influenced where birds landed and, hence, the probability of encountering bitumen (below).

2. Based on prior information, it would have been difficult to predict the precise landing locations on October 25 and 26. However, synthesizing the available literature would have anticipated the potential and approximate roles of adverse weather, lower deterrent densities, and proximity to the Athabasca River. The analyses in this report combined with analyses of both past and future landing events of smaller magnitude will make it possible to increase the predictability of landing events in space and time. No one has previously anticipated the combination of poor weather, geography, bird physiology, and the positions of deterrents, artificial lights, and bitumen that may best predict the specific locations of landings in this event.

3. Detailed analyses of the spatial correlates of bird recoveries in the October 25 and 26 landing event indicated that they were more likely

    a. On ponds that were closer to the Athabasca River with larger areas of shoreline that were unprotected by audio deterrence of 80 dB or greater,

    b. Within 200 m of shorelines on the down wind side of ponds, and

    c. In the vicinity of anthropogenic light stations that support mining operations.

4. More information is needed to assess the importance of both spatial and temporal variables, but several recommendations for research and mitigation are offered. Data of particular relevance include the distribution of both bitumen and anthropogenic light in the oil sands and the responses of birds to lights of different colours, intensities, and distributions. For more immediate use, the mitigation with the greatest promise includes use of green light instead of white, containment of bitumen, and the provision of alternative landing sites when periods of extreme weather and migration coincide.

A goldeneye drake in a pond containing process-affected water.
Photo by Dave Fairless

Chapter 3: Media analysis of the April 2008 landing event

Substantial media attention occurred following the 2008 landing event that was the subject of the court case, *R v Syncrude*. Media attention continued through the trial, conviction, and sentencing in that case, and also followed a subsequent landing event in 2010. Given the relative paucity of previous media attention to the environmental challenges posed by tailings ponds, the 2008 landing event constituted what sociologists would term *an environmental focusing event*. The nature of media attention during such events is assumed to influence public perception and subsequent environmental policy.

To assess the nature of media attention following the 2008 landing event, I sought collaboration with social scientist, Naomi Krogman of the University of Alberta to conduct a media analysis. Naomi and I co-supervised the work of undergraduate student Paul Nelson who was also supported by University of Alberta librarian, Lindsay Johnson. Although Paul was an undergraduate student at the time he began the media analysis, he did not conduct the work as part of a formal course and he continued to work on it throughout his master's degree in environmental sociology.

The title, authors, abstract, and a figure from this paper are reproduced below. As of March 2014, the paper is *in press* at the peer-reviewed journal, *Society and Natural Resources*. The paper can be found on the RAPP website (http://rapp.biology.ualberta.ca/)

This photo by Todd Powell was reprinted numerous times in the print media. The caption below accompanied it with an article in the Edmonton Journal by Hanneke Brooymans on 26 October 2010.

"Two dead mallard drakes float in a bitumen mat in the Syncrude Aurora Tailings Pond in April 2008 near Ft. Mc Murray, Alberta. Dozens of ducks were euthanized after landing on another Syncrude tailings pond Monday night.

Photograph by: Todd Powell , Fish and Wildlife Division of the Alberta Government."

Dead Ducks and Dirty Oil: Media Representations and Environmental Solutions

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Abstract

On April 28, 2008, over 1600 migrating ducks died after landing on a toxic tailings pond in the Oil Sands region of North-Eastern Alberta. The responsible company was found guilty and paid the largest environmental fine in Alberta's history. To assess the nature of this environmental focusing event we identified 747 newspaper articles that covered this event published between January 2008 and June 2011. Each article was coded based on date of publication, voices represented, and solutions proposed. The coverage was concentrated following the original and related events, creating a focusing event, and expressed mainly the voices of powerful actors in industry, government, and environmental groups. Most of the solutions proposed were short term and depicted a zero-sum trade-off between environmental and economic interests. We suggest that more sustained media attention with a greater diversity of voices and solutions could foster greater dialogue around environmental challenges like toxic tailings ponds.

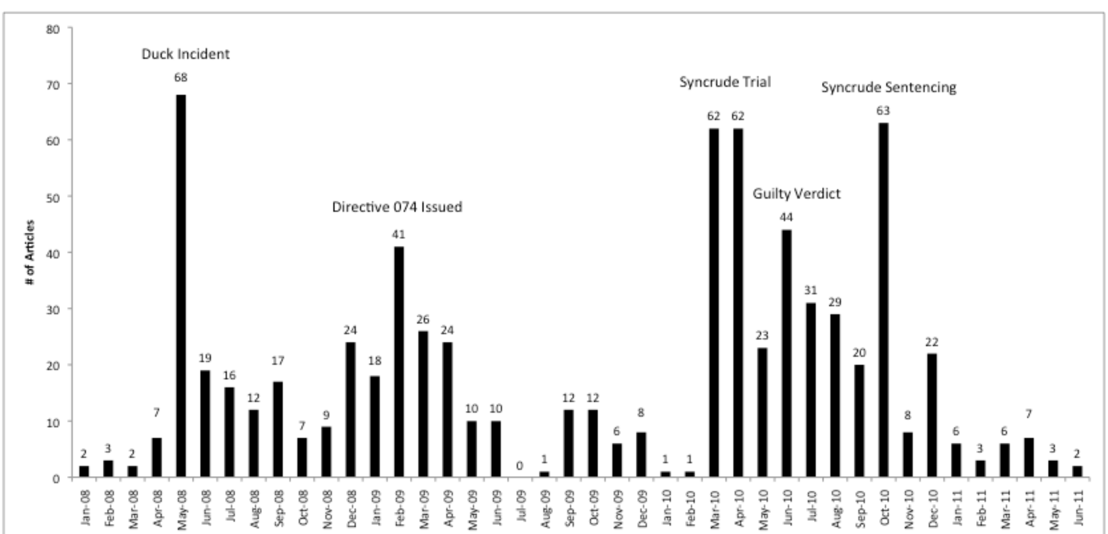


Figure 2.1. Number of newspaper articles published per month illustrating key events related to tailings ponds in Alberta that occurred between January 2008 and June 2011 (from Nelson *et al. In press*).

Section 2

Standardized Monitoring Program

Monitoring consisted of observing birds for specified lengths of time at both process-affected water ponds and freshwater ponds. Observers used range finders, compasses, binoculars and spotting scopes to identify and count birds and to record the azimuth and distance to each target.

Chapter 4: Development of a Standardized Bird Monitoring Program

Over the past four years, industry, government and academic representatives have collaborated to design and implement a standardized monitoring program to measure contact by birds with process-affected water ponds and resulting mortality. Participation in the program is a regulatory requirement specified under the annual permits to operate provided by government to each of the oil sands mining companies. In brief, the program involves daily surveys for live birds at over 80 monitoring stations, standardized mortality searches that are conducted twice monthly, and reporting of data in electronic databases. Several dozen individuals contribute to the program each year and some industry representatives suggested its cost, per operator, is approximately $2 million annually. The program is likely the largest cooperative and standardized monitoring program in the world of the effects on birds of any industry.

The 2014 Monitoring Plan can be found, along with the three other annual plans, on the RAPP website (http://rapp.biology.ualberta.ca/). This final protocol, and a description of the process that created it, is being prepared for submission to the open-access, peer-reviewed journal *PLoS One*. A summary of the annual changes to the program is provided in Table 4.1, below. In the paragraphs below, I explain the origin of the standardized bird monitoring program.

In 2009, Michael Aiton of Alberta Environment asked me to review the bird deterrent practices of the oil sands industry and to comment on the findings of a recent tour by compliance inspectors working for Alberta Environment. In turn, I invited Rob Ronconi, a former student and then Killam Postdoctoral Fellow at Dalhousie University, to assist me. One of the core findings of our 2010 report was the need for a standardized monitoring program to provide accurate and comparable information on the rate of bird contacts and mortalities at process-affected water ponds. That report is also available on the RAPP website (http://rapp.biology.ualberta.ca/).

In 2010, Alberta Environment required that operators submit a standardized monitoring plan, which industry contracted to Rob Ronconi. In that plan, Rob expanded on the recommendations contained in our earlier report to create a specific and standardized protocol with which to monitor bird contacts and mortalities in association with process-affected water ponds in the oil sands region (Ronconi 2011). A letter from the deputy minister obliged all five multi-national companies producing bitumen via surface mining to adhere to the protocol. With agreement by government, industry representatives invited me to advise on refinements to the program and to lead development of subsequent annual adjustments. They also asked me to receive, store and report on the data produced by it. I accepted this invitation because of the support it would provide to the goals of RAPP and received no compensation for it. I used RAPP funding to support the personnel, equipment, and field expenses associated with that work.

Together with my group at the University of Alberta, I have met with industry and government representatives several times per year in each of 2011, 2012, 2013 and 2014 and lead collaborative refinements to the program plan (St. Clair and Loots 2012; St. Clair, Loots, McCallum, and Ronconi 2013, St Clair et al. 2014). As part of that work, the U of A team developed tools and procedures to

- Count bird contacts and mortalities with standardized methods, tools, survey areas, visit durations, and visit frequencies;
- Enter data electronically via tablet computers in the field;
- Standardize the training of observers with a webinar-based training program;
- Assure the quality and standardization of data via review by a data manager;
- Conduct a study of inter-observer variation to support evaluation of the comparability of data among ponds, observers, lease sites, seasons, and years;
- Store data securely with automatic backups; and
- Identify annual refinements and remaining challenges.

Compilations and evaluations of the data emanating from the standardized program are contained in the annual reports produced by the U of A team (Chapter 5).

The table below summarizes the changes that have occurred in each year of the program as a result of collaborative discussion with industry and government representatives.

American wigeon in flight

Photo by Dave Fairless

Table 4.1. Summary of changes to the Oil Sands Bird Contact Monitoring Program between 2011 and 2014.

Topic	2011 Protocol	2012 Protocol	2013 Protocol	2014 Protocol
Survey stations	Allocate survey stations in relation to pond size and place them, when possible, at equidistant intervals on pond perimeters.	Increase the standardization of survey stations; last year's stations sometimes floated around the pond.	Designate permanent survey stations and mark them with barcodes; designate alternate stations when access is prevented.	Increase the permanence of survey markers where necessary and continue to use barcodes which have standardized station positions.
Training	Companies undertook all training of observers; at some lease sites, personnel were responsible for both hazing and observation.	Require that observers are trained in bird identification and do not have simultaneous responsibilities to haze birds.	Optional attendance at a webinar of ~ 3 h offered by U of A in April; the number of observers in attendance differed by operator.	U of A made the 2013 webinar available for use by all operators.
Measurement of inter-observer variation	Incidental assessment of inter-observer variation occurred at Shell's site owing to simultaneous work there by U of A and industry observers. Enormous differences also occurred among operators that could not	U of A initiated a study of inter-observer variation by visiting lease sites, travelling with industry observers, and conducting simultaneous, but independent surveys. Imperial, Syncrude and Shell participated in the	U of A observers visited the lease sites of all five oil sands companies multiple times in each of the spring and fall migration seasons. These data will be examined in detail to provide guidance on minimizing variation	In 2014, one day a week may be devoted to 'Comparison Days' for the purposes of training new observers, standardizing performance among observers, collating information about protocol standardization, or

	be explained by geography alone (e.g., species that were highly abundant at one site and absent at others; the absence of birds flying over at one site).	study in Spring and Fall; CNRL joined in Fall. Such visits were not conducted at Suncor.	among observers and to estimate detectability functions.	compensating for missed monitoring days. Details are provided under bird surveys.
Equipment	The monitoring plan specified that observers should use binoculars, range finders and spotting scopes, but many industry observers did not do so.	Equipment specifications were restated as recommendations, but variation remained among operators.	The protocol contained an explicit requirement that quality equipment with a minimum standard of magnification be available and used: spotting scope, binoculars, range finder, tripod, tablet.	Operators are to ensure that spotting scopes are used and mounted appropriately on tripods or window mounts at stations monitoring to 500 m.
Pond inclusion	The ponds that required monitoring was determined by previous permits for existing mines (Shell, Suncor, Syncrude), but included all ponds containing process-affected water at new mines (CNRL and	Examination of monitoring results demonstrated that there were inconsistencies among operators in the kinds of ponds that were to be monitored. The location of small ponds at CNRL and Imperial challenged observers to complete the protocol and	Discussion about eliminating some ponds occurred, but regulators determined that operators should monitor all ponds that were included in previous protocols.	Operators have the option of dropping from the daily monitoring program small ponds (< 1.5 ha) that recorded no landings or mortalities; detailed criteria are contained under procedural standards.

	Imperial).	some ponds were not monitored daily.		
Recording of pond characteristic s	U of A collected information about pond characteristics was collected for 40 ponds to examine the correlates of mortalities following the October 2010 event. Some of this information stemmed from inspection reports collected in Spring 2009 and reported on subsequently by U of A (Chapters 2 and 4).	Maps describing pond characteristics were expanded in detail and scope to 53 ponds. This work provided the first comprehensive and GIS-based assessment of pond characteristics for the industry. At the request of industry observers, U of A provided copies of maps to support protocol implementation.	A total of 64 ponds were described via GIS maps at three spatial scales. New information was added including the position of outflow pipes and the sums of waterbirds landing and mortalities of any bird species reported in association with tailings ponds.	Operators are to use the maps produced by U of A in 2013 to record the same pond characteristics, but in association with each survey station (i.e., up to four times per pond). Information for the recording of anthropogenic light may follow in 2013 or beyond.
Beach areas	Beach areas were to be included as part of the monitoring of process-affected water ponds, but confusion arose as to how it should be defined.	Uncertainty about what comprises beach and shore area continued with apparent differences among operators.	Survey area includes the water, shore that could be reached at any time of the year by changing water, and shore areas that are bare or vegetated.	Measure the distance between the survey station and (a) the current waterline and (b) the high-water mark for each of 3 directions on approximately May 1 and September 1 each year.
Bird inclusion	The protocol specified	A greater emphasis was	Observers were to restrict	Distinguish the landing

	that observers should record all birds seen or heard as both landings and fly-overs. Enormous variation among operators was reported for detections using different methods, occurring on different substrates, and designated to different species groups.	placed on recording both fly-overs and landed birds within a measured distance of 500 m; less emphasis was put on recording birds detected by hearing, particularly if they were not the waterbirds targeted by the program.	fly-over counts to birds that were BOTH below 100 m and within a horizontal distance of 500 m radius from the survey station. Observers were to be capable of recognizing species at risk by sound and sight and to record heard birds only for those species and novel species detected for the site.	location of birds as being (a) on water or (b) between the current waterline and the high-water mark and whether that area is wet or dry at the time of detection. The high water mark includes any area with visible bitumen or water residue.
Requirements for single observers	The protocol suggested that two observers should be used so that one could survey ponds while the other measured distances and recorded data.	Because it was apparent that several operators employed single observers, additional emphasis was placed on the need to compensate for reduced detectability owing to simultaneous observing and recording of data.	If there is a single observer who is also recording data, there ***must*** be a system to ensure standardization of observation time at either 10 or 30 minutes. Compensation systems could include use of a voice recorder or stopping the observation clock whenever data recording is occurring.	Use a new function on the tablet forms that stops the scan clock when single observers are looking at their tablets. Recording on tablets in real time is needed to support this function and a field for total elapsed scan times has been added to tablet forms.

Species at risk	Species at risk were identified and designated for additional reporting requirements.	No changes.	More explicit information was provided in the protocol about species at risk designations and the precise procedures to follow when they were detected.	Continue to emphasize species at risk in training and incidental recording and use all available cues (i.e. including sound) to identify species at risk.
Fly-overs	Observers were to report birds that flew over the survey stations within 500 m horizontal distance. Some operators reported no fly-overs and others reported fly-overs at considerably greater distances.	Variation in fly-over reports continued to be tremendously variable among operators, which weakened its utility for data comparisons.	Report only those flyovers that occur within 100 m immediately above survey stations.	Continue use of this threshold, but provide height references during training. Operators may provide additional information about flight patterns if desired as part of their comparison day work.
Mortality searches	Conduct mortality searches twice weekly on all process-affected ponds using boat and shore-based surveys; report the proportion of shore searched and the time spent searching.	No changes	Conduct mortality searches at each process-affected pond once every 2 weeks. Plan a survey route and record the route that was actually completed.	Standardize the three forms of mortality searches now taking place and conduct each type of search at least every two weeks. Detailed information is contained under mortality searches.

Morality reports	Record mortalities in the manner required by government.	Record mortalities in the manner required by government.	Record mortalities in a separate database via computer following collection of field notes.	Require use of standardized forms for each search type; homogenize the provincial and protocol requirements as per protocol refinements below.
Data submission	Make optional use of the tablet-based data entry system developed by U of A to reduce recording errors and time needed for data entry. U of A provided requested adjustments to forms between and within seasons in all years.	U of A requested that operators avoid changing the tablet forms unilaterally and required that they avoid mixing data submission by tablet and spreadsheet because of the thousands of coding errors, redundancies and omissions that resulted in 2011.	Submit data only via tablets or web-based forms; use paper data forms ***only*** on an interim or emergency basis.	Enter data in real time to support measurement of survey time (above); entered data can be transmitted to the data manager in a separate step.
Data checking	Began combing data at the end of the first season and discovered then many sources of unintended variation	Operators should quality check data at least once per season. U of A provided copies of uploaded data at least that often.	At the request of industry, U of A error-checked data weekly and send reports to operators. This was a time-consuming task, but there was not much	Designate an entity to ensure data checking occurs frequently (ideally weekly) to protect the value of the entire program. Additional

			evidence that the information was used. Many months of data checking occurred after the season was completed.	emphasis is needed on the standardization of mortality records.
Reporting	Industry invited U of A to write a report on their behalf summarizing the data needed for their annual operating permits.	Government requested a continuation of this reporting structure (Chapter 5) amid a preference by some operators to commission consultants to write their own reports.	Operators write reports for lease sites; U of A makes available a summary of all the data and writes a synthetic report for comparisons across industry.	Continue to compare data among operators with synthetic figures and analyses. Ensure that both individual and combined reports are produced with the same set of data.
Bird hazing	Between 2011-2013, bird hazing was not discussed as part of the OSBM Program.	Between 2011-2013, bird hazing was not discussed as part of the OSBM Program.	Between 2011-2013, bird hazing was not discussed as part of the OSBM Program.	Suggestions for standardization are contained under recommendations at the end of the 2014 protocol (Chapter 4).
Public involvement	Between 2011-2013, no public involvement in the OSBM occurred.	Between 2011-2013, no public involvement in the OSBM occurred.	Between 2011-2013, no public involvement in the OSBM occurred.	A suggestion to consider adding a component in 2014 or beyond is contained under recommendations below.

Chapter 5: Rates of Contact and Mortality of Birds with Process-affected Water

Three years of data have now been collected from the standardized monitoring program to provide, for the first time, a comprehensive, rigorous, and comparative assessment of the rates of contacts and mortalities by birds in the process-affected water ponds of the oil sands industry. With this information, it will be possible to compare deterrent system efficacy within and among sites to increase bird protection.

These data indicate that the deterrent systems deployed by oil sands companies do not prevent all birds from landing on the ponds. Observers recorded up to 20,000 landings by birds on process-affected water ponds annually and a conservative extrapolation from survey areas suggests the total number of contacts is 200,000. Yet fewer than 200 birds were recorded annually as mortalities in association with process-affected ponds. If this ratio (1/200 of the landed birds die) is accurate, the monitoring results suggest that birds can usually see bitumen and avoid landing in it. The sub-lethal effects of contact with process-affected water are poorly known, but investigated in Chapter 7 of this report.

In the paragraphs below, I explain the unconventional history of the reporting structure for the program and follow with excerpts from previous reports and contain as appendices to this report data summaries from the 2013 monitoring year.

In Fall 2011, during an in-person meeting that included government representatives from Alberta Environment and Alberta Sustainable Resource Development in addition to all five of the multi-national companies that operate oil sands mines, I was invited to report *on behalf of operators* on the data I had received from the then-named Regional Bird Monitoring Program. Industry led this invitation and government agreed to it. The logic was that I was already in receipt of the data, I was already poised to examine and report on it, and it was redundant for industry to do similar work independently. My synthetic report was to replace the annual reports describing bird contacts and landings that had previously been required of each operator as a condition of its permit to operate.

I was amenable to this invitation, seeing a detailed analysis of the monitoring data as a core means of advancing bird protection in the region in accordance with the court order in *R. v Syncrude*. Accordingly, I produced the *2011 Annual Report on the Regional Bird Monitoring Program for the Oil Sands*, which is contained on the RAPP website (http://rapp.biology.ualberta.ca/). The final version of that report was submitted on 23 February 2012, although the title page incorrectly states the submission date as 23 February 2011 (stemming from the reporting on 2011 data).

In Fall 2012, the Government of Alberta again requested that I produce an annual report on behalf of operators. I learned then that operators themselves wished to produce their own reports so as to retain ownership of report style and content and to avoid a situation in which delays to the production of the report could interfere with their 2013 permits to operate. Government representatives explained their preference for a combined report and supported it with direction to operators from the designated director under the provincial EPEA legislation. Subsequently, my assistants and I produced the *2012 Report of the Regional Bird Monitoring Program for the Oil Sands* for which the title, authors, preface, table of contents, and executive summary are reproduced below. This report and its five appendices and can be found on the RAPP website (http://rapp.biology.ualberta.ca/).

The final version of the 2012 report was not submitted until 28 May 28, 2013, three months later than the 2011 report. This delay was caused because I had a fall in early January 2012, which resulted in a concussion and four months of doctor-imposed medical leave. Extensions to the usual reporting deadlines were granted by AESRD.

In August 2013, representatives from government and industry met with me to discuss the reporting structure for the 2013 data. I proposed a hybrid between the 2012 industry request to complete annual reports independently and the government preference for me to complete a single report on behalf of operators. I acknowledged that the previous reporting deadlines had exacted heavy tolls on my group and that I understood the preference of industry to provide company and site-specific information. I also acknowledged the desirability of using a single data set to describe the products of the monitoring program. Specifically, I proposed the following procedure.

1. The U of A team would collate and error-check the 2013 monitoring data, continuing from weekly data checks that it had performed and communicated to operators throughout the 2013 season. It would then provide to each operator a groomed and final copy of its data for use in operator-generated annual reports.

2. Each operator would provide to the U of A team the attributes of each pond, including station locations and deterrent configurations for the production of an updated set of maps.

3. The U of A would provide maps, summary tables, and figures comparable to those contained in the 2012 monitoring report and make these available, when ready, on a secure website accessible to industry and government.

The following paragraphs provide a brief summary of these products. I have not produced a report comparable the one we generated with the 2012 data for two reasons. First, the corrected data are not yet available. Despite our mutual goal to complete data standardization in Fall, 2013, we continued to exchange information with operators through March 2014. More time will be needed to synthesize these results completely, which includes the development of detectability functions to correct counts of landed birds for over- and under-sampling at some sites, and differing distances to pond shorelines. Second, I will submit the products of this synthetic work to peer-reviewed journals, some of which require primacy of publication that would be compromised by containment of the same information in this public report. As an alternative to a synthetic report for the 2013 data, I provided the products listed above to government and industry representatives as drafts beginning in late January on a secure server site. We provided periodic updates as corrected data were available and the final versions of those resources coincide with the release of this report.

These products were compiled primarily by Aditya Gangadharan, Patrick Gilhooly, Julia Jackson, and Sarina Loots, who will be authors on a subsequent publication. To provide a home for the complete data set, they are contained as appendices to this report and they are stored on the RAPP website (http://rapp.biology.ualberta.ca/).

In **Appendix A, Table 1** provides definitions of the terms relevant to both the monitoring plan and previous monitoring reports.

Table 2 lists the attributes of 64 process-affected ponds and 7 freshwater ponds including their names and dates of origin; whether or not they contain bitumen, beach, vegetation or islands; the type of water they contain; their surface area and distance from the Athabasca River; information about the number, location and coverage of survey stations for live birds; information about the number, density, type, position and estimated acoustic coverage of deterrents; the number of birds recorded as landings from the target guilds (dabbles, dives or wades) and mortalities associated with the pond; and the survey methods and amount of effort spent searching for mortalities.

Table 3 lists the attributes of the species actually or plausibly detected as part of the monitoring program in 2013 includes foraging guild, taxonomic information and status under species at risk designations.

Table 4 lists the name and risk status for all species detected in 2013 and provides counts of birds, divided by operators and as totals, for records stemming from each of fly-overs v landings. The table is divided between process-affected ponds and freshwater ponds.

Table 5 lists counts of landed birds from the target guilds for each season and operator, again with separate panels for process-affected and freshwater ponds.

Table 6 lists the incidental observations anywhere on lease sites of live birds by species, risk status, and operator. Separate panels describe reports by industry and U of A observers.

Table 7 lists the numbers of mortalities, by species and Alberta risk status, that were detected in association with process-affected water ponds. Mortalities are further attributed to search method (designated search v incidental report) and operator.

Table 8 lists counts of birds, by species and risk designation, that were detected during simultaneous surveys by industry and U of A observers. Separate panels describe counts at process-affected and freshwater ponds.

Table 9 lists by season the species at risk that flew over or landed on process-affected water on any of the lease sites in the mineable oil sands.

Table 10 summarizes all of the species at risk that were detected as fly-overs, landings, or mortalities between 2011 and 2013 on process-affected and freshwater ponds. The operator(s) that detected each species are also listed.

Appendix B provides a series of multi-layer (i.e., GIS) maps that include an overview of the region (**Figure 1**; scale = 1:362 761), a summary of each lease site (**Figure 2**; scale = 1:100,000) and a detailed presentation of each pond (**Figure 2**; scale = 1:20 000). Each of the 55 detailed maps contains information on the location and type of deterrent devices along with their calculated spatial extent of coverage, the location and presumed survey area of each monitoring station for live birds, the position of outflow pipes, and a summary of the number of live birds of the target guilds (i.e., birds that forage by diving, dabbling or wading) and mortalities associated with process-affected ponds. An example of these maps is contained below (Figure 5.1).

Appendix C contains the remainder of the figures, which summarize the information contained in the tables and corresponds to similar figures in the 2012 report.

Figure 3 describes the number of live birds that were reported as flying over v landing at each of the seven lease sites and separately for process-affected and freshwater ponds. An example of these figures is provided below.

Figure 4 standardizes detections of live birds per 10 minutes of observation and divides records by foraging guild and position (fly-over v landing), again separating process-affected and freshwater ponds.

Figure 5 expresses the total landings at process-affected ponds by the target guilds among the spring, summer, and fall seasons and separately for percent of detections and total counts of birds.

Figure 6 describes the rate of bird detections (per 10 minutes) and the number of survey periods for each 2-hour block since sunrise. Data are compiled separately for process-affected ponds and freshwater ponds and for all guilds and only target guilds.

Figure 7 shows detections per observation session for all bird guilds from simultaneous observations by industry and U of A observers for combined seasons (spring and fall), but separated by operator and between process-affected and freshwater ponds.

Figure 8 compares counts by industry and U of A observers at process-affected ponds with separate plots for each of the target guilds (dabbles, dives and wades) and operators. Another set of panels lists comparisons between industry and U of A for all guilds with a separate panel for each operator.

Figure 9 describes the number of mortalities reported by each operator for each guild (dabbler, diver, wader, other / unknown duck, and total).

Figure 10 compiles the number of mortalities attributed to each species of dabbler, diver, wader and other birds that were oiled and identifies the species that are listed as sensitive or special concern.

Figure 11 describes the number of mortalities of oiled birds and non-oiled target birds that were reported each month during 2013.

Figure 12 distinguishes birds that were ultimately recorded as mortalities as a function of whether they were alive or dead when they were first detected. At the direction of AESRD, live birds with substantial oil on their feathers must be euthanized.

Figure 13 distinguishes between birds that were reported as incidental v search-based detections for each of the five operators.

Figure 14 describes the amount of time spent searching for mortalities by the method of boating, walking, and driving for each of the five operators.

Figure 15 describes the number of mortalities detected with each of the search modes (boating, walking, driving) by each of the five operators.

Table 5.1. Example of the 66 pages of tables contained in Appendix A of this report that summarize data from the 2013 year of the *Oil Sands Bird Contact Monitoring Program*.

Table 4A. Counts of bird landings and flyovers, by operator and total, for process-affected ponds in 2013.

Common name	Alberta Risk Status	CNRL - Horizon		Imperial - Kearl		Shell - Jackpine	
		Landed	Flyover	Landed	Flyover	Landed	Flyover
Greater White-fronted Goose	Secure	5	30	0	0	0	454
Snow Goose	Secure	1	168	0	3	0	148
Canada Goose	Secure	195	1385	56	1637	0	953
Tundra Swan	Secure	0	0	0	5	0	157
Gadwall	Secure	13	4	1	1	0	0
American Wigeon	Secure	65	37	6	4	0	0
Mallard	Secure	753	438	225	22	4	2
Blue-winged Teal	Secure	10	0	0	1	0	0
Northern Shoveler	Secure	155	31	10	2	0	2
Northern Pintail	Sensitive	74	80	3	0	2	4
Green-winged Teal	Sensitive	221	24	26	1	0	0
UNK Dabbler		72	85	14	58	9	2
UNK Dabbler Non-duck		0	0	6	0	0	0
UNK Goose		0	10	0	0	0	1
UNK Swan		0	1	0	0	0	0
Canvasback	Secure	92	0	18	0	0	0
Redhead	Secure	13	0	2	0	0	0
Ring-necked Duck	Secure	61	0	10	0	0	0
Greater Scaup	Secure	116	0	13	0	0	0
Lesser Scaup	Sensitive	120	1	115	0	3	0
Surf Scoter	Secure	21	0	1	0	6	0
White-winged Scoter	Special Concern	0	2	0	2	0	0
Long-tailed Duck	Secure	40	0	0	0	0	0
Bufflehead	Secure	31	5	75	0	2	4
Common Goldeneye	Secure	220	18	346	53	0	0
Barrow's Goldeneye	Secure	0	0	0	2	0	0
Hooded Merganser	Secure	0	0	2	0	0	0
Common Merganser	Secure	3	5	2	0	2	0
Red-breasted Merganser	Secure	0	0	0	0	0	0
Ruddy Duck	Secure	94	0	18	0	0	0
Common Loon	Secure	11	5	135	5	0	1
Pied-billed Grebe	Sensitive	1	0	2	0	0	0
Western Grebe	Special Concern	1	0	0	0	0	0
American White Pelican	Sensitive	1	2	0	0	0	0
Double-crested Cormorant	Secure	1	0	0	0	0	0
Black Tern	Sensitive	0	1	3	10	0	3
Common Tern	Secure	0	0	51	58	0	0
Arctic Tern	Secure	0	0	0	0	0	0
Belted Kingfisher	Secure	0	0	0	0	0	0
Eared Grebe	Secure	48	0	11	0	2	0
Horned Grebe	Sensitive	18	0	22	0	0	0
Red-necked Grebe	Secure	18	0	19	0	0	0
UNK Diver		4	2	0	1	0	0
UNK Diver Duck		11	12	269	27	7	0
UNK Duck		26	203	1	0	0	4
UNK Grebe		0	0	0	0	0	0
UNK Merganser		1	0	0	0	0	0
UNK Scaup		511	23	0	0	3	0
UNK Tern		0	0	0	4	0	0
Great Blue Heron	Sensitive	0	2	2	3	0	2
American Coot	Secure	7	0	11	0	0	0
Sandhill Crane	Sensitive	11	52	21	113	0	0
Whooping Crane	At Risk	0	0	0	30	0	0

Figure 5.1. Example of the 55 pages of maps (scale = 1:20,000) contained in Appendix B of this report that were produced to describe the 64 ponds containing process-affected water on the lease sites of oil sands mining companies.

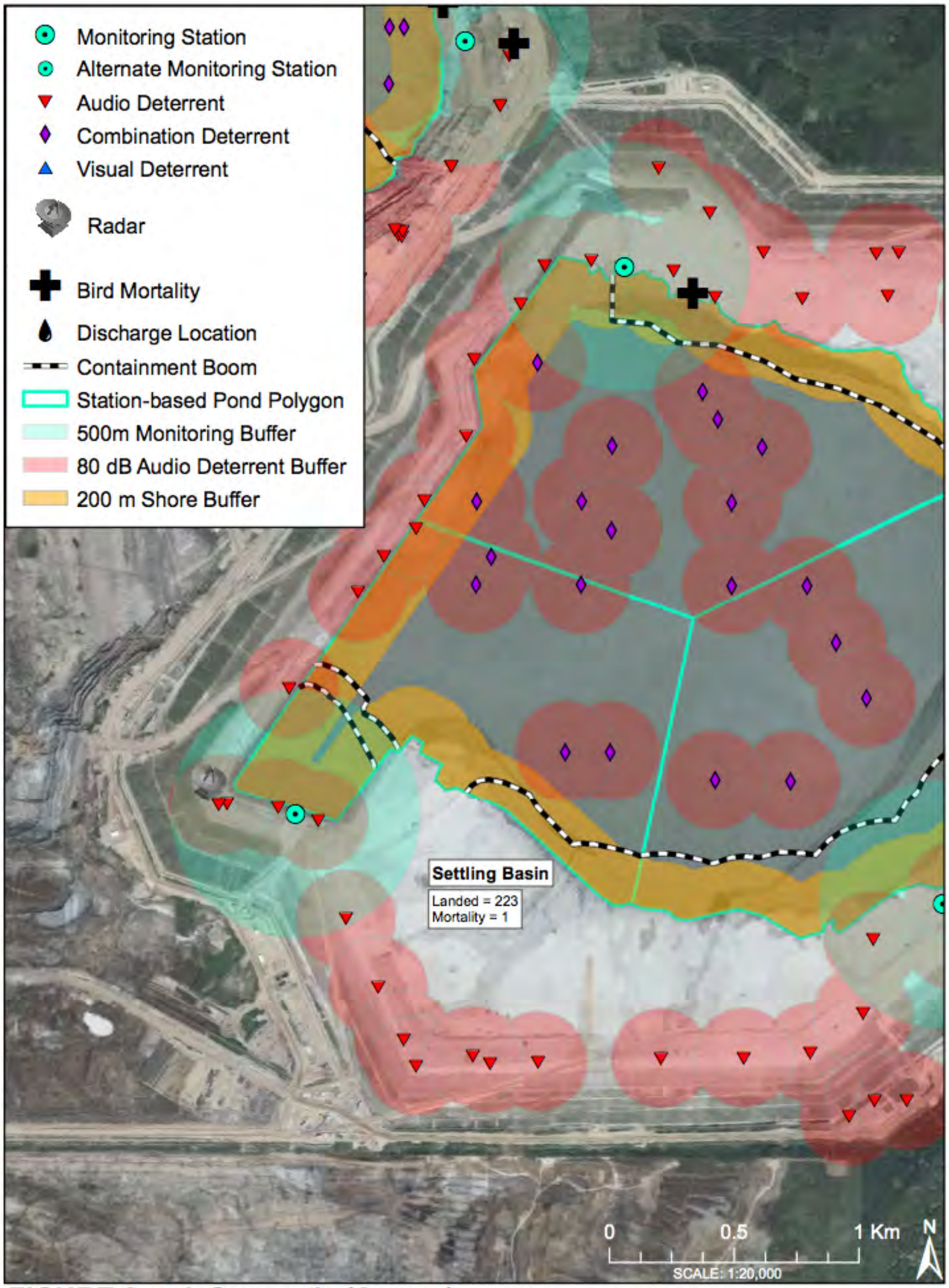


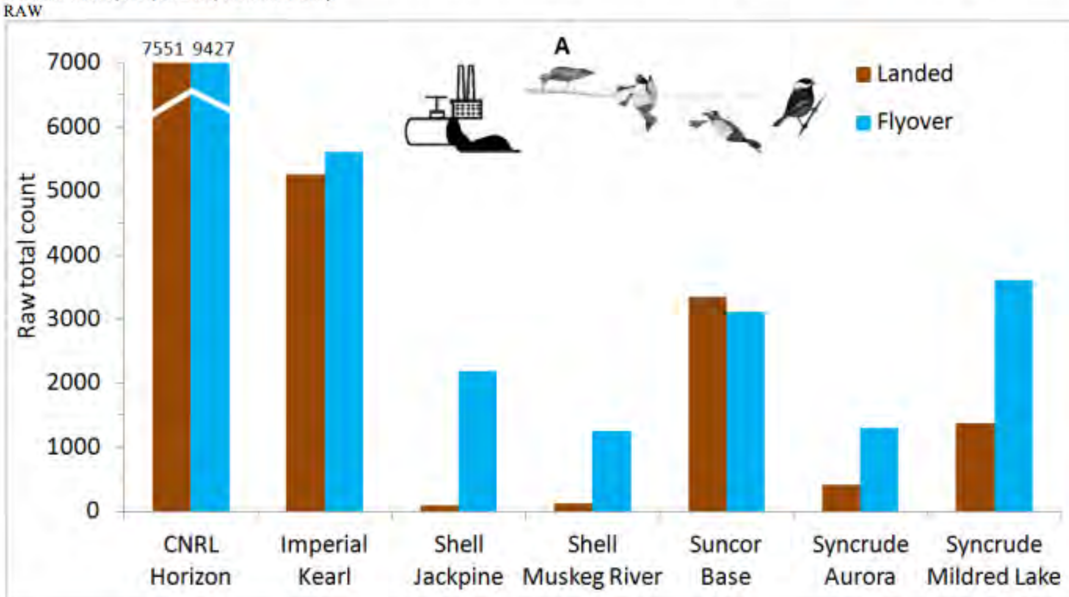
FIGURE 2. e. i. Syncrude (Aurora)

Figure 5.2. Example of the 34 pages of figures contained in Appendix C of this report that summarize data on live birds and mortalities from the 2013 year of the *Oil Sands Bird Contact Monitoring Program*.

Figure 3 Number of birds flying over *vs.* landed

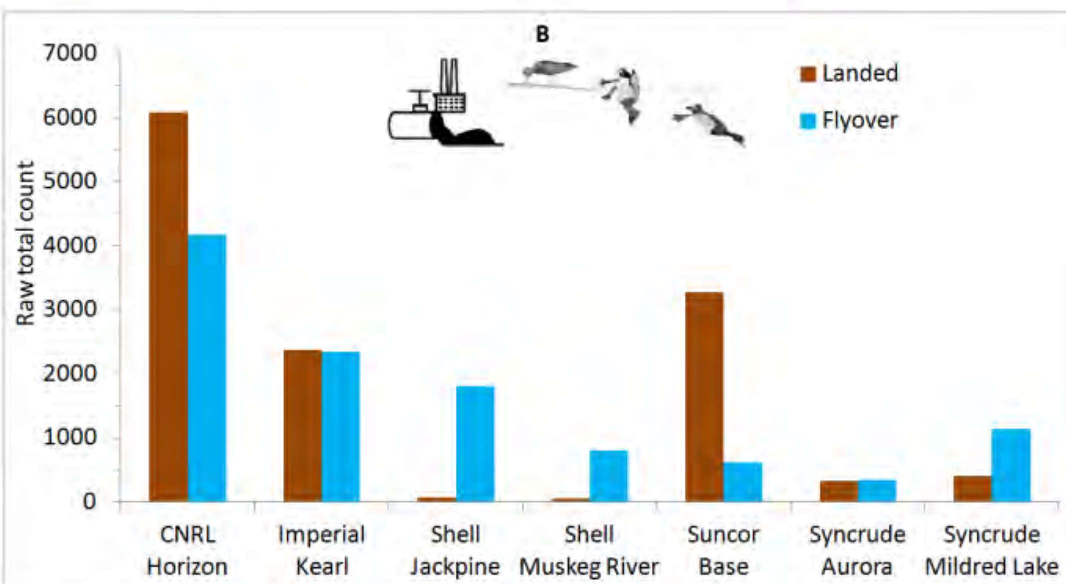
Total number of birds detected flying over *vs.* landed for each operator. Results are tallied separately for process-affected water ponds (Panels A and B) and for freshwater ponds (Panels C and D) and for all guilds (Panels A and C) and for only those in the three foraging guilds targeted by the monitoring program (i.e., birds that dabble, dive, or wade; Panels B and D).

RAW



Final Report of the Research on Avian Protection Project *C. C. St. Clair* *April 2014*

Chapter 5, Appendix C. Monitoring Figures 2



Section 3

Field and laboratory studies

Field and laboratory studies addressed automated monitoring by camera and radar, visual deterrent techniques, and toxicological effects of process-affected water on ducks. Studies were conducted in the oil sands and at or near the University of Alberta.

Chapter 6: Automated methods for the detection of birds

On March 1, 2011, as RAPP was beginning, I met with industry representatives to refine the protocol for the 2011 Regional Bird Monitoring Program (Chapter 4). As part of that discussion, I mentioned my belief that it would soon be possible to monitor birds photographically and recounted examples of this application I had heard about at the recent North American Ornithological Congress.

Several industry representatives were enthusiastic about this possibility and a senior manager at Suncor asked me to describe in writing precisely what equipment would be needed. Accordingly, I developed the *Prospectus for Automated Monitoring in the Oil Sands* and sent it to all operators on 1 April 2011. I proposed that individual operators could participate in a pilot project to test the equipment and that such a collaborative approach to research could support an application to the Natural Science and Engineering Research Council (NSERC). The prospectus is available under background information on the RAPP website (http://rapp.biology.ualberta.ca/).

Imperial Oil responded to this invitation in 2011 and subsequently established a Research Agreement to fund it. That work included the development of a stand-alone high-resolution camera attached to an automatic panning head powered by deep cycle batteries and contained in a modified bear-proof garbage can. The unit could monitor the entire pond surface and operate without human intervention for up to three days. It was tested at Kearl Compensation Lake. Manual use of the system occurred at several other sites to determine its ability to replace human observers. Results of these tests are contained in the thesis of Sarina Loots (below). Sarina also explored the potential to use video and wildlife cameras for bird monitoring.

Another automated monitoring technology, marine radar, is now employed by all five of the oil sands companies. These systems integrate the detection of birds via radar with a computer that interprets its signals and then deploys deterrents via radio signals. A former student, Rob Ronconi, and I tested the first installation of this type in 2003 at Shell's Muskeg River Mine (that paper can be found on the RAPP website: http://rapp.biology.ualberta.ca/). From that experience, I was aware of some of the limitations of marine radar in the accurate detection of birds and their implications for bird protection. Whereas false negatives could mean that relevant targets were not subjected to deterrents, false positives could lead to habituation through over-use of deterrents. The second chapter of Sarina's thesis identifies several factors that determine the rate with which radar-based detections correlate with those by human observers. A draft abstract of her thesis, which will be defended on May 23, follows.

Automated bird monitoring techniques vary in their performance when compared to human observers at industrial water bodies.

Draft abstract of thesis by Sarina Loots, to be defended on 25 May 2014

Conflict occurs between people and birds at industrial sites around the world, where birds can endanger human lives (e.g. airports) and where bird populations are endangered by human activities (e.g. wind farms). Mitigating these risks requires accurate detection of birds and measures of their abundance and distribution. At industrial sites, detection of flying birds is often automated with avian radar. Additionally, radar detections are sometimes programmed to trigger algorithms that deploy avian deterrents. This technique is applied at oil sands mining operations in northern Alberta, because the industry produces waste-water ponds that sometimes attract waterfowl. These ponds pose particular risk to waterfowl when they migrate over the oil sands in the spring and fall and the oil sands industry is required to prevent birds from contacting these ponds. I tested two technologies for detecting birds in this context, one for detecting flying birds (radar), and one for detecting birds that have landed (cameras).

I tested radar to establish its accuracy for detecting flying birds in the oil sands area, based on birds detected by paired human observers. I used X-band marine radar fitted with two types of radar antennas, one parabolic and one open-array. I tested the radar antennas across a range of conditions, at both process-affected water ponds and freshwater ponds. My results indicate that marine radar does not detect all the birds that are present at industrial sites, and our two antennas failed to detect about half of all detections confirmed by visual observers. My results suggest that antenna type, height of radar survey station, and site-specific knowledge of target birds should be more explicitly addressed when marine radar is used as part of bird protection programs.

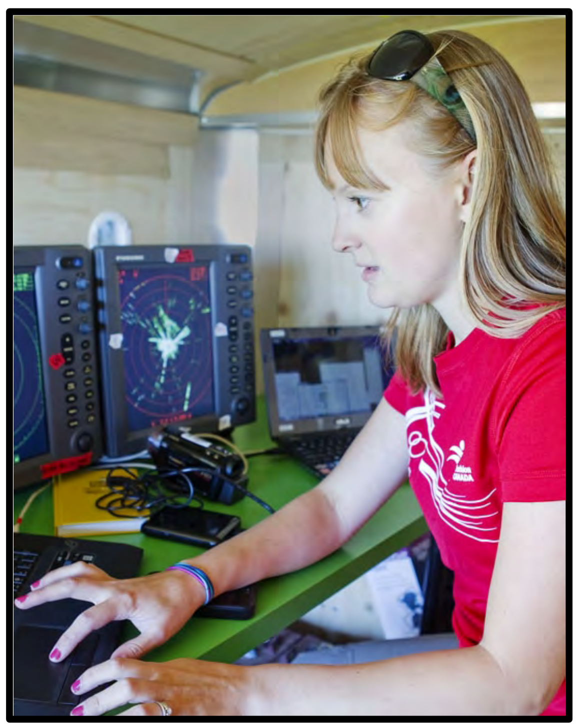
I also tested cameras to monitor birds in the context of industrial ponds. Birds that have landed on ponds are not detectable by radar, and standardised monitoring by human observers has documented the tens of thousands of birds landing annually on oil sands waste-water ponds. Such counts provide important for information on bird distribution and abundance, but they are limited by safety and inter-observer variability. We evaluated the potential for cameras to monitor birds on industrial water bodies by comparing counts from high-resolution photos, in the form of panoramas, and stationary wildlife cameras to counts conducted by field observers.

High-resolution cameras in a panoramic configuration recorded two-thirds of the birds recorded during the simultaneous field count, during 30-minute sessions for distances of up to 800 m from the survey station. Conventional wildlife cameras also recorded around two-thirds of birds in photos clearly when they were programmed with time-lapse settings, but only to a distance of 100 m. Compared to wildlife cameras, single-lens reflex cameras offer at least five times greater range, and can operate independently for up to 3 days. Both the single-frame SLR panoramas and the single-frame wildlife photos failed to capture birds that dove, birds that were behind other birds, and birds with oblique aspects to the camera. These birds could be detected by *capturing birds on time-interval settings with motion that revealed their presence. Time-interval settings also allowed for automated processing of photos.*

I explored a computer algorithm developed by collaborators to process photos by detecting motion in successive images. Automated processing of time-interval photos of birds produced a very high true negative rate (95%). This suggests that it can reduce the time spent by humans to process photos substantially. Sensitivity of the bird detection code can be further improved by tailoring its settings for each position of a deployed camera on time-interval. The combined application of high resolution cameras set to take photos at frequent intervals and a specialized bird detection code makes cameras a viable alternative to human observers at an accuracy of greater than 65% with the ability to exclude cases without birds at a success rate of 95%.

The two greatest limitations of automated techniques for bird monitoring are site-specific constraints and the distinction of target birds. Site-specific constraints for radar include installation characteristics (antenna, station height, surrounding substrate) and for cameras include specialization of the automated processing settings for each position in which the cameras are deployed. Most ecological monitoring applications have specific target birds, and species information is difficult to achieve using automated methods. These limitations can be accounted for through ground-truthing and cross-reference with other detection techniques. Radar and cameras have complementary roles to play in bird monitoring and protection at industrial sites.

Sarina Loots identified several factors that determine the accuracy with which marine radar detects flying birds. Photo by St. Albert Gazette.



Chapter 7: Toxicological effects on birds of process-affected water

Early in the development of the RAPP, I discussed the issue of toxicity of oil sands process-affected water ponds with several individuals who worked for many years in industry or on this issue. I relied mainly on the information provided by Doug Forsyth (Environment Canada), John Gulley (Golder Associates, Limited), Darrell Martindale (Shell Canada, Limited) and Mike McKinnon (Syncrude Canada, Limited). Their observations suggested that birds can land on process-affected water ponds without obvious ill effect, if they do not come in contact with fresh tailings or bitumen.

Extensive use of fresh water in the process used to extract bitumen from sand causes the industry to create large ponds of so-called process-affected water, which is recycled several times in the mining process, but cannot be released back into the environment. Typically, only a small fraction of the surface area of these ponds receives fresh tailings or contains residual bitumen at a given time. Yet the regulatory obligation to prevent birds from contacting any process-affected water results in deterrent practices that target broad spatial and temporal scales. That practice is likely to cause habituation that reduces the efficacy of deterrents at the times and locations that pose the most extreme danger to birds; fresh tailings and bitumen mats. Responsible recommendations to change these deterrent practices are predicated on the assumption that brief landings on other forms of process-affected water are not harmful to birds, but there is almost no literature to assess that assumption directly.

These circumstances prompted me to seek collaboration with a toxicologist, Judit Smits of the University of Calgary, to conduct an experiment on captive birds. With collaboration from Shell Canada Limited, we obtained process-affected water from the recycle water pond at the Muskeg River Mine and subjected captive ducks to it repeatedly. We measured the effects of exposure on their health with blood-based assays and compared these analytes to birds that had been exposed to well water.

This experiment was completed by M.Sc. student Elizabeth Beck, who also conducted a literature review on the toxicological effects on birds of exposure to process-affected water and related constituents. A main conclusion of her thesis, which she defended on 29 April 2014, is that there is little evidence of toxicological effects on captive ducks from process-affected, recycled water. This work is in review at the *Journal of Environmental Science and Technology* as E.M. Beck, J.E.G. Smits, and C.C. St. Clair. "Health of Domestic Mallards (*Anas platyrhynchos domestica*) Following Exposure to Oil Sands Process-Affected Water." A revision of the paper was invited on 28 April 2014. Elizabeth's literature review will be submitted to *Journal of Conservation Physiology*.

The Effects of Oil Sands Process-Affected Water on Waterfowl

Thesis abstract of Elizabeth Meagan Beck who defended on 29 April 2014

The oil sands landscape in northern Alberta is interspersed with large tailings ponds that hold wastewater from bitumen mining and extraction processes. Recent monitoring results indicate that many thousands of birds, mostly migrating waterfowl, land annually on the ponds associated with this industry, but very few appear to die because of that contact. Mortalities are typically associated with bitumen exposure, which coats bird feathers to prevent flight, flotation, and thermoregulation. The recent awareness that many birds land creates an urgent need to understand the sublethal effects of contact with other pond constituents such as naphthenic acids, polycyclic aromatic hydrocarbons, and metals.

In this thesis, I reviewed the toxicological effects on birds of exposure to oil sands process-affected water and inferred potential toxicities of untested effects using a broader literature. There are few descriptions in the peer-reviewed literature of these effects, but some studies suggest that exposure to it causes reproductive disorders, alterations in endocrine and immune function, and changes in growth, metabolism, and population structure. To address the paucity of studies on waterfowl, I conducted a field experiment to emulate the repeated, short-term exposures to process-affected water that migrating water birds might experience in the oil sands. Pekin ducks (Anas platyrhynchos domestica) were exposed to recycled process-affected water without visible bitumen. Each exposure consisted of placing an individual bird in a plastic tub containing approximately 15 L of either process-affected water or tap water (controls) for 6 – 8 hours. Birds were exposed three times as juveniles and six times as adults. I assessed toxicity by evaluating body mass and a suite of biochemical, endocrinological, hematological, and metal residues in the birds. Results provided little evidence of toxicity. Relative to controls, juvenile birds exposed to process-affected water had higher potassium, and lower bicarbonate and cholesterol following the final exposure period, and juvenile males had a higher thyroid hormone ratio (T3/T4). Adult birds exposed to process-affected water had higher levels of vanadium and lower GGT, and, following the final exposure period, higher bicarbonate. Adult female treated birds had higher bile acid, globulin, and molybdenum levels, whereas adult males exhibited higher levels of corticosterone. However, even for the analytes that differed significantly, means were within standard reference intervals for birds, suggesting the absence of significant biological or toxicological effects.

While it is premature to assume that ponds containing recycled water are not toxic to birds, the literature review combined with my own field experiment suggest that these ponds are less dangerous than ponds containing bitumen and fresh tailings. More work

will be needed to determine the generality of these results. However, for ponds that are not acutely lethal to birds and do not elicit chronic or sublethal effects, current deterrent efforts might be relaxed. This change would permit higher deterrent intensity at the more toxic ponds. This scenario contrasts with the current practices, which apply similar deterrent efforts across all types of process-affected ponds, potentially reducing, via habituation, bird protection from the constituents – bitumen and fresh tailings – that are most likely to cause mortality.

Elizabeth Beck took blood samples from domestic ducks to determine the effects of exposure to process-affected water. The entire RAPP crew assisted in raising young ducks in 2011.

Chapter 8: Deterrent practices to support better bird protection

At most of the oil sands operations, bird detection via marine radar is integrated with bird deterrence via sophisticated electronic equipment. Both components are important for effective bird protection. To deter birds from their flight paths or to prevent them from landing on process-affected ponds, deterrent systems must create stimuli that occur in the right place, at the right time, and with relevance to the target species.

Current deterrent practices in the oil sands mining industry rely almost exclusively on audio deterrents. Traditionally, these consisted of propane cannons that were set to fire at regular intervals and deployed in groups to create a cacophony of random-sounding bangs. More recent acoustic devices are based on libraries of electronic sounds that are amplified with speakers. These have the advantage of providing more diverse and stimuli with greater evolutionary relevance (e.g., predator sounds), which is presumed to reduce the rate with which birds habituate to the sounds. Modern acoustic devices can produce sound intensities as great as 156 dB, enough to permanently deafen a human, or other animal, nearby (Chapter 2).

Visual deterrents are much less developed in the oil sands industry. Traditional visual deterrents consisted of stationary scarecrows made of rebar and dressed in the clothing of duck hunters or mine workers. Several operators now employ effigies of birds of prey that move with mechanical or wind-based mechanisms. Some operators supplement their acoustic systems with lasers that broadcast moving beams.

All five oil sands operators rely on a combination of integrated electronic systems and traditional stand-alone deterrents in their bird protection systems. In the past decade, there has been a shift toward systems that operate over much larger spatial scales wherein a single radar unit and a few satellite speakers may be installed to protect an entire tailings pond of several km^2. To date, there is no peer-reviewed test of the efficacy of these large integrated deterrent systems relative to the deployment of more devices at smaller spatial scales. Analyses of data from the 2012 standardized monitoring program (Chapter 4) suggest that the smaller-scale deterrents correlate with fewer landings.

Ffion Cassidy will complete her M.Sc. thesis later this year. Her work explores a variety of visual deterrent devices that can be operated at small spatial scales to supplement acoustic deterrent systems. The goal of the work is to identify stimuli that exploit the sensory systems and evolutionary ecology of birds to maximize their efficacy while minimizing their cost and potential for collateral damage to ecosystems. An abstract written by Ffion of her intended thesis work follows.

Testing visual deterrent efficacy for mitigation of bird-human conflicts

Abstract of prospective thesis to be completed in 2014 by Ffion Cassidy

The potential for human-wildlife conflict grows rapidly with increased global industrialization, especially where human infrastructure overlaps with areas of high wildlife use. Conflict is often mitigated by attempting to deter wildlife from specific areas, but wildlife frequently habituate to deterrent devices. Better deterrence systems are urgently needed to protect birds in many industrial and transportation contexts. This is particularly true in the oil sands region of northern Alberta, where open pit mining produces large tailings ponds containing bitumen and other toxic substances. These ponds are directly below a major migratory flyway used by huge numbers of waterfowl from throughout North America. Avian contact with this water violates two Federal and one Provincial pieces of legislation so oil sands operators are obliged to prevent all landing events. Current protection strategies include effigies and high intensity acoustic deterrents, but standardized monitoring shows that many thousands of birds still land on tailings ponds annually in spite of the efforts to deter them.

In general, multi-modal deterrent strategies are more effective than those exploiting a single sensory stimulus. Because birds rely heavily on vision to obtain information about their environment, the development of visual deterrents to complement acoustic practices is a logical step. We applied theory from the field of sensory ecology to assess what attributes of visual deterrents affect their efficacy on waterbirds (ducks, geese, gulls, and shorebirds).

The first objective was to test the efficacy of visual deterrents, such as predator models and exclusion treatments, which might modify the local site use by birds. The second objective was to assess the efficacy of lasers as visual deterrents which could be used for larger scale applications. Fieldwork was conducted around Edmonton, AB on natural and man-made ponds which are attractive to waterbirds.

To address the first objective, floating visual deterrents were grouped by the type of risk they portrayed (predator, non-predator) and the type of stimulus they utilised (realistic, novel/"supernormal"). Fences and barriers designed to impede water/shore access were installed as shoreline deterrents and were grouped by the level of obstruction they presented (high or low) and their deployment location (water or shore). Bird use of the land or water surrounding these deterrent or exclusion devices was monitored using remote cameras. We will evaluate deterrent effects on bird abundance and proximity for patterns across bird sex and foraging guild, and weather, as well as the attributes of the deterrents.

To address the second objective, we tested the efficacy of lasers as low-light, long distance deterrents. The few existing studies examining the effects of lasers indicate large variation in bird response, and we tested biological characteristics (sex, species, foraging guild, reproductive status) as well as abiotic factors (weather, season) that may explain this variation. Birds were targeted with either green or violet lasers, and their response was recorded on an ordinal scale from no response to departure from the area.

Identifying the most salient types of visual stimuli, rather than specific devices, which impact deterrent efficacy will aid in the development of the most useful visual deterrents. These results for visual deterrents can then be used in combination with acoustic practices to afford small scale, highly specific, effective protection in areas which present particularly high risk to birds. This research will significantly advance bird protection in the oil sands and other industrial contexts.

Ffion Cassidy made extensive use of remote cameras to study the reaction of waterbirds to visual deterrents of a variety of types.

Chapter 9: Research projects by undergraduate students.

Over the 3.5 year course of RAPP, 7 students completed full or half-year capstone undergraduate research projects that addressed some aspect of the original or evolving RAPP objectives. Their work provided baseline reviews of the literature and pilot work to inform the development of graduate theses (above). I provide below brief synopses of these projects in chronological order of completion.

Joelyn Kozar (Winter 2011) reviewed the annual bird protection plan reports produced by John Gulley of Golder Associates for Suncor Energy between 1975 and 1992. Her work showed that thousands of birds from the target guild were detected in the vicinity of the mine site each year but that both monitoring intensity and the number of birds reported dropped precipitously in 1986 following a labour dispute. It appears that the intensity of bird monitoring never returned to previous levels, which had been about three times as frequent before the dispute. Joelyn's work also compiled the number of dead birds associated with Suncor's early tailings ponds (Ponds 1, 2, 3, and 4) over those 25 years which summed to approximately 1700 individuals.

Mallory Nault (Winter 2011) reviewed the deterrence literature for bird protection at industrial sites. Her review identified lasers and stimuli with evolutionary relevance as particularly promising tools for avian deterrence. Mallory also identified some deterrent types, including bird balls and objects that manipulate the Earth's magnetic field, that I had not previously encountered in the deterrence literature. This review informed the thesis work of Ffion Cassidy (Chapter 9).

Patrick Welsh (Winter 2011; co-supervised by Keith Tierney, U of A toxicologist) conducted a broad review of the literature on toxicological effects of hydrocarbons, such as oil and bitumen, on birds. As others have done, Patrick identified bitumen, naphthenic acids and polyaromatic hydrocarbons as the most harmful components of process-affected water for birds. Elizabeth Beck benefitted from Patrick's earlier work in her own assessment of the literature for her thesis (Chapter 8).

Steve Pasichnuk (Summer 2011) reviewed the potential to use infra-red (IR) illumination as part of the automated camera protocol in the thesis work of Sarina Loots (Chapter 7 above). His review and calculations showed that automated monitoring of birds at night could be supported with IR lasers and IR-sensitive cameras for a fraction of the cost of conventional thermal cameras. Despite the feasibility of this method, we decided it was not practical to use IR illumination to view birds at night with the spatial scales necessary for monitoring in the oil sands region.

Stephan Pacholak (Summer 2012) conducted a pilot experiment with deterrents that formed the basis for some of the experiments conducted by Ffion Cassidy (Chapter 9). In particular, Stephan demonstrated that a model of a coyote can deter birds from beach areas temporarily, but that birds eventually habituate to the stationary object.

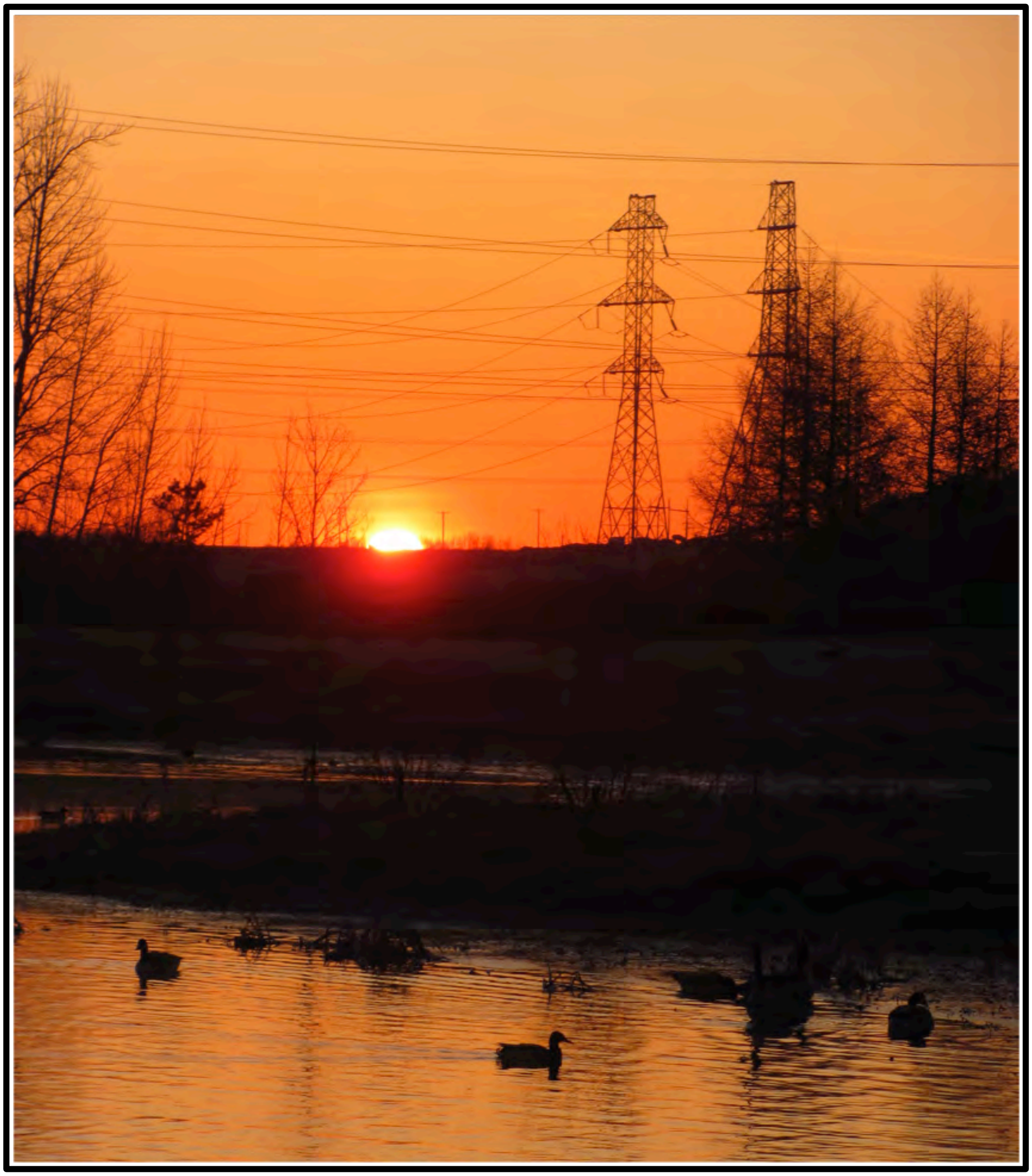
Seann Murdock (Winter 2012; co-supervised by Ted Allison, U of A physiologist) reviewed the avian literature to determine which bird species have been documented to have the ability to see UV light, whether the species appears to use UV refracted from feathers in mate choice, and the wavelength of peak sensitivity to UV light. His work contributed to the design of our experiments with lasers (Chapter 8) and development of best practices (Chapter 12).

Sierra Sullivan (Fall-Winter 2011-12; co-supervised by Keith Tierney) conducted an ambitious, two-factor laboratory experiment that exposed fish larvae to light and sound pollution to assess their effects on larval development. Her project exhibited very high within-treatment variability which prevent robust conclusions about the effects of either source of pollution and the way these might interact with process-affected water. Subsequent students in Keith's lab have continued to investigate these effects.

Mike Habberfield, a visiting Ph. D. student from SUNY Buffalo, conducted an experiment to determine if ultra-violet light could deter songbirds from feeders in Winter 2010, before RAPP began. The purpose of that work was to test the lights as a method of reducing window strikes by birds. Several RAPP assistants later assisted in the processing of the data from that experiment (Summer and Fall 2011), which is being prepared now for publication in a peer-reviewed journal.

Section 4

Accounting



Chapter 10: RAPP Opportunities for knowledge exchange

RAPP provided tremendous and diverse opportunities for knowledge exchange of both traditional and non-traditional forms. I summarize the educational opportunities and collaborations associated with RAPP below. Several of the products of this work are described in greater detail in other chapters of this report. Knowledge flowed in multiple directions; my students and I benefited tremendously from exposure to the inner workings of industry, consulting, and government.

Research opportunities for students. In addition to the three graduate students I supervised directly, RAPP provided funding for one additional M.Sc. student working on bird protection in the oil sands region under the supervision of University of Calgary toxicologist, Judit Smits. A total of eight undergraduate students conducted independent research projects as part of RAPP. In addition to independent projects, RAPP hosted many students as research assistants and provided training to other students as part of courses. These included two interns from the WISEST (Women in Scholarship, Engineering, Science and Technology) program in each of the summers of 2011 and 2012, 21 research assistants over the three field seasons of RAPP work. Ten additional students were trained in the standardized monitoring protocol (Chapter 5) as part of a course I taught in field ecology (Biology 432) and one of these secured a job in the industry as a monitor this summer because of that experience. Two other former students from my lab have been employed by the oil sands industry as bird monitors.

Career development for professional biologists. The size and complexity of RAPP created the need for administrative support and advanced analytical work that was beyond the scope of undergraduate assistants or graduate thesis work. The project employed four technologists full time for periods of one or two years between November 2010 and November 2013. One of these was based at the Acadia University where he worked with collaborator Phil Taylor on the development of open-source radar software. Appointments to support technical aspects of the project, particularly for the standardized monitoring program, offered employment as technicians or graduate research assistants to 12 additional individuals, each of whom built on their repertoires of skills as professional biologists.

Collaboration, protocol development and training for industry. Development of the standardized monitoring program (Chapter 4 and 5) resulted three or four in-person, all-day meetings annually with representatives from government and industry. Typically, I led much of the content of those meetings by facilitating discussion of draft protocols and their refinements, presenting preliminary results and future plans, and discussing aspects of program governance and data management. Meeting attendees included one or two representatives from each of the five oil sands companies, the provincial

Department of AESRD, and the federal Canadian Wildlife Service. Protocols support was offered to approximately 10 additional industry workers annually who, in turn, each supervised up to 20 other industry employees and consultants. In 2013, we developed a training webinar and delivered it to approximately 30 individuals. That resource remains available for use by industry or others in 2014 and beyond.

Resources for government. Throughout RAPP, I had extensive and frequent conversations with the lead government biologist for Alberta Environment and Sustainable Resource Development, with less frequent and sometimes indirect interactions with several other provincial government employees. I presented three seminars to employees at Environment Canada, including one to the director general of the Canadian Wildlife Service. Each of these contexts had a primary emphasis on the standardized monitoring program and its regulatory implications. Specific to our work on deterrents, we also engaged with the department of Integrated Pest Management at the City of Edmonton and worked extensively with them to plan, execute, and report on deterrent work based in city parks where waterfowl, particularly Canada Goose, create conflict via abundant feces on shore and in the water.

Educational material for other educational institutions. At the request of other instructors, I have presented seminars on RAPP work to my home department (Spring 2011 and 2014), an interdisciplinary course hosted by the law department (Summers 2011 and 2012), and members of the incoming class in veterinary medicine, University of Calgary (Fall 2013). I have met on three occasions (2011, 2012, 2013) with representatives of Keyano College to discuss knowledge exchange for their environment program and offered them use of our RAPP training webinar.

Collaborations with academics. I invited collaboration with several colleagues to support aspects of RAPP for which I lacked sufficient expertise. In my own department, Erin Bayne undertook acoustic monitoring in the region and Keith Tierney supported work by Patrick Welsh and Sierra Sullivan on toxicological effects of process-affected water. Naomi Krogman of the Department of Resource Economics and Environmental Sociology supported the media analysis by Paul Nelson. Hong Zhang of the Department of Computing Sciences produced codes to detect birds from video files and, with Erin Bayne, assisted Sarina Loots with thesis plans. Rob Ronconi, then of Dalhousie University, produced the 2011 monitoring plan on which all subsequent plans were based and continued to provided feedback on monitoring protocols. Phil Taylor of Acadia University supported our work on radar. Judit Smits of the University of Calgary co-supervised the work of Elizabeth Beck on toxicology.

Public awareness. RAPP has attracted some public interest via the media throughout its period of activity.

Media. Several media outlets provided news reports of the original research project (Fall 2011), feature articles in local newspapers and radio describing aspects of our work (several annually), summaries of our findings in the newsletters of interest groups (e.g., *Oil Sands Review* and *Wilderness Advocate*) and news reporting of our monitoring results (front page *Edmonton Journal*, July 2013). Some of the media attention RAPP received is contained as links on the RAPP website (http://rapp.biology.ualberta.ca/).

Public seminars. We have presented publicly-advertised seminars of our work in the Calgary Lecture Series of the University of Alberta outreach (Winter 2012) and the Edmonton Nature Club (Winter 2013). With the completion of RAPP in Spring 2014, I will seek opportunities to communicate its finding to wider public audiences and I have posted a recent version of this seminar on the publicly-accessible RAPP website (http://rapp.biology.ualberta.ca/).

Informal engagement. We engaged the public in a variety of informal ways throughout RAPP via casual discussion (e.g., at the campground in the oil sands and at city parks where we trialed deterrents), answers to questions from the public and a variety of corporations via phone or email, and, in one case, by hosting a team of 12-year-old ringette players for a spring break 'science day' in our lab.

Conference presentations. We presented aspects of our work on RAPP at several conferences as follows

- Local: RE Peter Biological Symposium (2013, 2014)
- Regional and National: Alberta Chapter of The Wildlife Society (2012, 2013, 2014); Society of Environmental Toxicology and Chemistry, Prairie and Northern Region (2013); The Wildlife Society, Canada Section (2013)
- International: The Wildlife Society (Fall 2013); The Ecological Society of North America (2012), The North American Ornithological Congress (2012) [No RAPP funds were used to support travel outside of Alberta as specified in the order.]

Reports

As part of our work with government, we produced the following reports:

- A report on the October 2010 Landing Event (2012)
- Annual Protocols to support the Regional Bird Monitoring Program (2011, 2012, 2013, and 2014; Chapter 4)
- Report on the Regional Bird Monitoring Program (2012 and 2013; Chapter 5)

Publications. Submission to peer-reviewed journals is in progress or planned for several of the products of RAPP including components described in Chapters 2 – 9, plus 12 and 13 of this report. Chapters 2 (Media Analysis) is *in press*, and part of Chapter 7 (Toxicology) is *in review*. In all, I anticipate at least 10 publications in the peer-reviewed literature will result from RAPP over the coming few years. Publications will be posted on the RAPP website as they become available (http://rapp.biology.ualberta.ca/).

American advocets gathered each fall at one of the sites near Edmonton where we tested visual deterrents. Shorebirds typically ignore acoustic deterrents but, apparently, they are not afraid of 'scary eyes' either.

Table 10.1. Summary of education, training, and knowledge exchange for individuals afforded by RAPP

Number	Type	Associated programs
4	High school summer students	WISEST
8	Undergraduate research projects	Department of Biological Sciences, University of Alberta
4	M.Sc. projects	Department of Biological Sciences, University of Alberta and Faculty of Veterinary Medicine, University of Calgary
21	UG students and UG-level research assistants	RAPP objectives 1, 2 and 3
6	Graduate research assistants	RAPP objectives 2, 3, and 4
6	Technicians	RAPP objectives 2 and 3
10[1]	Discussion with industry and government representatives	Oil sands mining companies, AESRD, CWS
30[1]	Industry employees and sub-contractors involved in standardized monitoring	Oil Sands Bird Contact Monitoring Program
10	Presentations to individuals external to the RAPP program and its governance	Various
10	Number of peer-reviewed publications anticipated to result from RAPP	Various disciplinary journals

[1] Approximate total annually

Chapter 11: Project Expenditures

This chapter provides an itemized accounting summary of RAPP expenditures.

Appendix B, *Research on Avian Protection Project Administrative Framework*, of the court order from R. v Syncrude estimated financial resources would be allocated as follows

Item	**Court order**
Salaries and honorariums for postdoctoral fellow, M.Sc. students, field assistants, advisory committee, administrative support	$700,000.00
Costs of field research including travel, accommodations, vehicles and their maintenance, and field equipment	$400,000.00
Other equipment such as computers, software and office support	$135,000.00
Provision for 'administrative expenses' (overhead)	$65,000.00
Total	$1,300,000.00

The actual expenses of RAPP are summarized to 30 April 2014 with the researcher-accessible portion of the U of A financial software in Table 11.1. As required by the court, the University of Alberta will have submitted a complete Financial Statement for the project by 31 May 2014 to: the Provincial Court of Alberta Criminal Division; the Environmental Coordinator Regulatory Prosecutions, Alberta Justice; and the Director of the Public Prosecution Service of Canada. Additional information is tallied in this report for expenditures on major equipment, including computers, (Table 11.2) and salaries (Table 11.3).

In addition to the funding afforded by the court, RAPP benefited from several donations by others (Table 11.4), which included the teaching release (Department of Biological Sciences), waiving of overhead (Faculty of Science), provision of campground space, power, and water (The Lewyk Park Campground), and unpaid time. I have estimated the value of time with average salaries to make these donations visible. I received no salary for my work on RAPP, but I consider such work to be appropriate for my position as a professor at a publicly-funded university.

Table 11.1. Financial overview of RAPP expenditures 1 Nov 2010 - 30 April 2014.

UNIVERSITY OF ALBERTA

Favorites Main Menu > Employee Self-Service > Projects > Researcher Home Page*

Financial Overview - Flash Report

Project:	RES0008567	SCL Court Order 090157926P1 Research Grants - External	**Project Type:**	BUDBA
			Status:	Open
Holder:	Colleen St Clair	Principal Investigator	**Start Date:**	11/30/2010
Department:	360150	SCI Biological Sciences	**End Date:**	04/30/2014
SpeedCode:	2310B			

Awarded Amounts

Award Period	Budget Start Date	Budget End Date	Direct Cost	Included in Funds Available	Indirect Cost	Total
	11/01/2010	11/29/2010	0.00		0.00	
1	11/30/2010	11/29/2011	1,300,000.00	✓	0.00	1,300,000.00
2	11/30/2011	11/29/2012	0.00		0.00	
3	11/30/2012	11/29/2013	0.00		0.00	
4	11/30/2013	04/30/2014	0.00		0.00	
			1,300,000.00		**0.00**	**1,300,000.00**

Award and Expense Summary for the period: 11/01/2010 - 04/30/2014

Opening Balance / (Over Expenditure) as of 11/01/2010			
Direct Cost Budget	$1,300,000.00		
Funds Available before expenditures (A):		**$1,300,000.00**	
Expenditures			
Salaries and Benefits-BL	$685,912.50		
Supplies and Other-BL	$304,039.92		
Professional and Tech Ser-BL	$20,094.19		
Travel-BL	$17,517.56		
Equipment and Vehicles-BL	$270,028.16		
Total expenses (B)		**$1,297,592.33**	
Funds Available after expenditures as of 04/30/2014 (A-B):		**$2,407.67**	

Outstanding and Upcoming Milestones

Past Due	Due Date	Sponsor	Milestone	Milestone Details
	05/31/2014	Syncrude Canada Ltd	FinStmt(SRE)signed by PI	Nov 30, 2010 - Apr 30/14 Per Appendix B, #4. - Submit copies to 1. Provincial Court of Alberta Criminal Division; 2. Environmental Coordinator Regulatory Prosecutions, Alberta Justice; 3. Director of the Public Prosecution Service of Canada

NB: The apparent surplus of $2446.91 is nominal and will be 0 in the final accounting when all project expenses have been processed.

Table 11.2. Summary of RAPP expenditures on major equipment, including computers (as requested by the order) and other equipment

Category	Item	Make and Model	Quantity	Total Cost
Computing	Desktop	DELL	1	$700
Computing	Desktop	Antec	1	$1,200
Computing	Desktop	ThinkCentre	1	$2,500
Computing	Desktop	Macintosh iMac 12.2 - 27"	1	$2,300
Computing	Desktop	Macintosh iMac 12.2 - 27"	1	$2,300
Computing	Laptop	Macbook pro Air	1	$1,000
Computing	Laptop	ASUS 17"	1	$1,500
Computing	Laptop	ASUS 15.6"	1	$800
Computing	Laptop	ASUS Notebook G73Sw	1	$1,300
Computing	Laptop	Toshiba TECRA R700	1	$700
Computing	Laptop	Toshiba 15.6"	1	$1,000
Computing	Tablets	Samsung Galaxy Tablets	5	$2,000
Computing	Data Storage	40 TB Data Storage system	1	$5,000
Computing Total				**$22,300**
Data recording	Gigapan	GigaPan EPIC Pro for DSLR Cameras	3	$2,400
Data recording	Marine Radar	Furuno Marine Radar with antenna	2	$30,000
Data recording	Reconyx camera	PC900 HyperFire Professional	30	$21,000
Data recording	Songmeter	Songmeters (SM2, SM2+, GPS)	49	$34,300
Data recording	Camera	Nikon Camera D700 lens	2	$11,200
Data recording	Camera	Nikon Camera D7000	1	$1,700
Observation	Spotting scope	Zeiss Diascope 85 mm and eye piece	3	$16,500
Transportation	Truck 4x4	2011 - Chevrolet Silverado	2	$60,000
Transportation	SUV	2008 - (Used) Ford Escape Hybrid	1	$21,500
Transportation	Travel Trailer	2011 - Columbia Aliner Ranger	1	$16,600
Transportation	Camper	2007 - (Used) Trillium Outback	1	$13,400
Transportation	Cargo Trailer	Cargo Mate - Challenger (to haul gear)	1	$3,100
Transportation	Utility Trailer	Cargo Mate - Blazer 950 (to house radar)	1	$2,500
Transportation	Kayaks	Pelican 10ft	2	$1,140
Transportation	Zodiac	ZEBEC Canada 7ft	1	$1,665
Transportation	Air vehicle	Zephyr 2 - UAV	1	$10,000
Major Equipment Total				**$247,005**

NB: The Zephyr 2 UAV was not delivered by a manufacturer in the US. Legal experts at the U of A attempted to recover the deposit, but were not successful.

Table 11.3. Summary of RAPP salary and benefit expenditures.

ID	Position	Total Salary	Benefits
1	Graduate RA	$23,464.08	$1,264.89
3	Graduate RA	$14,283.47	$725.69
9	Graduate RA	$35,091.21	$1,649.76
15	Graduate RA	$16,839.41	$711.87
22	Graduate RA	$762.58	$0.00
23	Graduate RA	$70,764.82	$3,022.33
6	Technician	$33,892.92	$2,605.50
16	Technician	$83,624.08	$6,348.98
17	Technician	$50,801.32	$3,870.82
24	Technician	$60,420.60	$4,425.38
29	Technician	$2,425.51	$176.66
32	Technician	$7,953.44	$575.99
20	UG student	$9,152.00	$656.31
21	UG student	$608.40	$42.28
26	UG student	$1,824.08	$117.83
28	UG student	$10,253.45	$746.28
30	UG student	$3,474.26	$209.01
33	UG student	$23,029.02	$1,595.95
4	UG-level assistant	$4,590.04	$339.55
5	UG-level assistant	$9,817.59	$725.16
7	UG-level assistant	$7,011.35	$589.80
8	UG-level assistant	$10,327.58	$767.26
11	UG-level assistant	$28,843.38	$2,117.57
12	UG-level assistant	$9,145.97	$2,094.96
13	UG-level assistant	$20,711.83	$1,542.81
14	UG-level assistant	$23,535.48	$1,753.79
18	UG-level assistant	$1,803.36	$90.86
19	UG-level assistant	$28,480.29	$1,943.42
25	UG-level assistant	$6,311.07	$443.01
27	UG-level assistant	$12,020.31	$925.19
31	UG-level assistant	$1,015.78	$72.59
34	UG-level assistant	$6,502.55	$480.69
35	UG-level assistant	$18,289.66	$1,323.35
	Total	**$645,902.31**	**$43,955.54**

Table 11.4. Estimated value of subsidies to RAPP provided by Th University of Alberta, a campground owner, and RAPP personnel. The values of time for individuals are based on estimates of average wages.

Source of subsidy	Type	Amount	Value	Notes
Biological Sciences, U of A	teaching release	1 course * 3 yrs	$27,000	1
Faculty of Science, U of A	waiving of overhead	specified in order	$65,000	2
Tim Lewyk, Lewyk Camp	waiving of camp fee	$1000 / mth * 6 * 3 yrs	$18,000	3
Overtime	M.Sc. Students	3 students * 2 yrs * 25%	$33,000	4
Volunteerism	UG Students	9 student terms * 10 * 100	$9,000	5
Overtime	PI	3.5 yrs * 10%	$35,000	6
Expert Witness Report	PI	preparation and stand	$9,000	7
Total			$196,000	

Notes: (1) based on wages for sessional lecturers; (2) offered by former Dean, Greg Taylor; (3) donated by campground owner because of the nature of the work we were doing; (4) estimated hours of graduate students; (5) estimated length required to complete a UG project course; (6) estimated net increase in my work load to host RAPP; (7) an invoice based on average rates for time served as an expert witness (preparation of report and time on stand) in R v Syncrude. I decided not to submit the invoice after being invited to host RAPP.

Future use of RAPP equipment

Alberta Justice has indicated that equipment purchased with RAPP funds is to remain the property of the University of Alberta with me as its representative. I will use this equipment and lend it to colleagues for research on bird protection and similar projects. I continue to conduct solution-oriented research on bird protection in the oil sands with two current graduate students. Discussions will continue at the completion of the court-ordered project for collaborative, solution-oriented research on avian protection that were invited by

- Syncrude Canada, Limited
- Imperial Oil, Limited
- Aerial Imaging Solutions, Inc.
- Accipiter Radar, Inc.

My current priorities for that research are to

- Measure the distribution and intensity of anthropogenic light and explore correlates with landings and mortalities in the standardized monitoring program;
- Use both landing and mortality data at the spatial resolution of observation stations (up to four per pond) or finer to assess the effect on birds of current deterrent practices. Existing pond-level analyses are too coarse to support refinements to deterrent practices within lease sites.
- Advance deterrent systems that exploit the sensory ecology and evolutionary history of birds to maximize aversive stimuli while minimizing environmental and economic costs.
- Assess the health of birds exposed to process-affected water and other constituents of the mineable oil sands industry using non-invasive markers contained in sexually-selected traits.
- Integrate deterrence, detection, and deflection (which I have named a 3D approach to bird protection) by using cameras and radar to detect birds, linked with or contained in robotic devices that that can deploy stimuli that deter birds from the area or, as a last resort, deflect them from imminent danger such as landing in bitumen.

I welcome inquiries from others interested in bird protection at any time.

Section 5

Synthesis and best practices

The Horned Grebe, a species at risk in Alberta, builds its nest on floating vegetation. Young chicks ride on the backs of the parents and may even dive with them. Forty-four Horned Grebes were recorded as landed on process-affected water ponds in the 2013 monitoring season. Photo by Dave Fairless.

Chapter 12: Recommendations for avian protection

To illustrate the changes in operational practices that might occur in future, I have created a table with columns dedicated to (a) common perceptions about the broader context of bird protection in the oil sands, (b) information from RAPP that bears on those perceptions, and (c) recommendations that result from my synthesis of this information (Table 12.1). The order of rows is guided by the chronology of chapters in this report, which are referenced in the second column.

Some explanations and caveats are warranted for these operational recommendations. First, although the court order (Chapter 1) specified that Syncrude is to consider any reasonable recommendations I offer here, many of them are already well underway at Syncrude and other mining operations. Secondly, I have based these ideas on existing technologies, but I have no engineering or mining expertise with which to evaluate the practicality of the suggestions. Finally, not all of these ideas originated with me; I have received at least as many ideas from others in industry, government, academia and the public as I have offered in return. I offer this summary as a resource for discussion without an intention of binding requirements.

Following this table of operational recommendations, I provide some prose that describes longer-term and more philosophical goals that might apply beyond Alberta and the oil sands industry. These include some commentary on philosophical, social, and political dimensions of bird protection in the mineable oil sands.

Booms can be an effective way to contain oil products, including bitumen. Booms with weighted curtains may make it possible to segregate process-affected water of different risk levels for birds to increase the efficacy of deterrents where they are needed most.

Table 12.1. Perceptions expressed at the outset of RAPP, information collected by RAPP that bears on those perceptions, and recommendations stemming from that information for future operational changes by the mineable oil sands industry.

Perception	RAPP Information	Operational recommendation
1. Mass landings happen rarely and cannot be predicted.	The three known landing events suggest that foul weather, darkness, proximity to a migratory corridor and the presence of anthropogenic light in the vicinity of bitumen can increase the likelihood of mass mortality events (Chapter 2).	a. Continue to combine information from the literature, media reports of mass landings by birds elsewhere, and data from the standardized monitoring program to refine and test the hypotheses in the report on the Oct 2010 landing event. b. If they are supported, develop procedures specific to storm events during migratory seasons. Adjustments could include: • Attraction to safer areas within ponds via decoys, • Heightened deterrence in the vicinity of bitumen, • Turning off, shielding or colour manipulation of lights in the vicinity of bitumen.
2. The news media provides diverse and balanced information about tailings ponds.	News reports associated with the mass landing and mortality events in the oil sands emphasized technological solutions and the dichotomous views of government, industry, and one environmental group; little voice was given to members of a wider public (Chapter 3).	a. Ensure monitoring is rigorous, comparable, and spatially-explicit and that its results are transparent and publicly-accessible. b. Use that information to improve and defend deterrent practices. c. Share both kinds of information to inform a diverse public about bird protection in the oil sands and its complexity.

3. No one is accurately counting the birds that land or die.	Development of a standardized monitoring program over the past three years provides rigorous, transparent, and defensible information about the rates of landings and mortalities (Chapter 4).	a. Continue to support the standardized monitoring program with a goal of increasing its efficiency to minimize costs while maintaining the quality and comparability of information over time. b. Increase the accuracy of the monitoring program as data become available to • Generate site-specific detectability functions, • Determine the representativeness of sampling stations and mortality search protocols, • Estimate variability over time to determine optimal sampling frequency.
4. Counting birds is straight-forward and no particular training or equipment is necessary.	Annual reports of the monitoring data demonstrated that tremendous variation in counts occurs among operators and between industry and U of A observers. Variation between observers declined in later years, apparently in response to better training, stricter adherence to protocols, and standardization of observation equipment. Responses to a U of A questionnaire to observers placed	a. Continue to provide detailed and standardized training for observers and ensure that they are proficient in completing the protocol as written. b. Assess the utility of the on-going training and standardization within lease sites afforded by the day per week allocated to this purpose in the 2014 protocol. c. Ensure that adequate equipment is provided and used by observers, including quality binoculars, range finder, spotting scope, tripod, tablet for data entry. d. Continue to conduct quality assurance and quality control on all monitoring data at regular intervals (i.e., as specificed in the

	high value on the provision of a common training session (Chapter 4).	annual plan) to protect data quality and inter-annual comparisons. e. Investigate the potential to use existing and new information from fly-over birds to assess the efficacy of deterrents (e.g., by changes in flight direction or altitude).
5. Landings by birds occur relatively infrequently on PAW ponds.	Tens, probably hundreds, of thousands of birds contact PAW ponds annually; there are substantial differences in the rates of contact and mortality among operators, ponds, seasons, and observers (Chapter 5).	a. Distinguish PAW ponds, and pond areas, by type. b. Segregate PAW of different toxicities. c. Intensify deterrence for the more toxic areas and ponds. d. Initiative discussions with regulators about the current presumption that birds must be similarly protected from all PAW. e. Engage relevant interest groups throughout North America who may be concerned that 'their' birds are landing on PAW.
6. Many dead birds could remain undetected.	The rate of detections during designated searches is extremely low and few mortalities are detected by any method, relative to landings. Mortality searches currently cover a small proportion of pond surfaces and more comprehensive and standardized methods will be needed to determine the generality of this	a. Increase the standardization of mortality searches in accordance with the 2014 monitoring plan to ensure the rigour of this conclusion. b. Use dredging or similar sampling to demonstrate that dead birds do not remain undetected at the bottom of ponds.

	result.	
7. Integration of bird detection by radar and deterrence with loud acoustic devices is superior to traditional scare cannons.	Analyses of the 2012 monitoring data suggest that increasing deterrent density reduces the rate of landing, but there is no effect of maximizing the area protected by high-intensity acoustic devices (Chapter 5). Examination of the 2013 data is ongoing. It appears that ponds with floating deterrents have fewer landings than ponds without such deterrents (Chapter 5).	a. Conduct site-specific analyses that contrast the rates of landings and mortalities in relation to pond characteristics. b. Integrate spatial, temporal, and species variables to identify the circumstances with the greatest potential risk to birds. Relevant variables include pond and deterrent characteristics, anthropogenic light, weather and seasonal effects, and many attributes of species such as breeding chronology, mating system, vision capacity, risk status, and responses to deterrent stimuli. c. Pay particular attention to the collateral ecological damage potentially caused by very loud acoustic devices and the benefits of water-based deterrents at higher densities. d. Share information among operators to tailor deterrent practices to maximize the efficacy of deterrent systems.
8. It will be necessary to monitor birds with human observers indefinitely	Work by Sarina Loots indicates that high resolution cameras can detect comparable numbers of birds to industry observers for existing survey radii (500 m) and that lower-resolution cameras can detect birds on the smallest size class of ponds (< 1.5; Chapter 6).	a. Allow operators to use camera-based monitoring of birds where it can increase operator safety or efficiency without compromising program rigour. b. Compare camera-based information explicitly to refine assessments of its accuracy and practicality. c. Consider using cameras to overcome the current tendency for monitoring to be concentrated at mid-day whereas bird detections peak in the morning and evening (Chapter 5, Figure

		6).
9. Marine radar is an accurate method for detecting birds	Work by Sarina Loots suggests that relative to human observers, marine radar is 2 to 2.5 times more likely to exhibit false negatives and that antenna type, installation height, substrate and bird characteristics interact to influence detection accuracy (Chapter 6).	a. Use existing information and extend it to determine the factors that influence radar accuracy and adjust installations accordingly. b. Work with providers of deterrent systems to steadily reduce the rate of false negatives, which can prevent deterrents from being deployed, and false positives, which can induce habituation.
10. Landing anywhere on PAW ponds is deadly for birds.	Toxicological work by Elizabeth Beck suggests that there are few measureable effects of PAW from a recycle pond on the health of birds and that none exceed the reference ranges of healthy birds (Chapter 7).	a. Conduct additional work to determine the toxicity for birds of PAW of a variety of types. Aim to separate the effects of air-water, and dust-borne contaminants. b. Refine existing methods (e.g., booms) to segregate water with different toxicity (e.g., fresh from mature tailings). c. Determine the health status of birds that live on or near PAW ponds and attempt to separate health differences with appropriate controls both before and after exposure.
11. Bitumen is extremely hazardous for birds	Mortalities reported in association with tailings ponds from the standardized monitoring program almost always exhibited bitumen (Chapter 5). A literature review by Elizabeth	a. Maximize efforts to deter birds from areas that contain residual bitumen, which may require lessening deterrence effort on adjacent water bodies. b. Collect additional research to determine the effects of PAW on birds, including birds that stop briefly on PAW ponds and then migrate to other destinations. Evaluate the hypothesis that

	Beck indicates that hydrocarbons are highly toxic to bird eggs and compromise several functions for adult birds (Chapter 7).	contaminants can be spread in this way to more pristine areas.
12. Lasers provide a cost-effective and comprehensive solution for deterring birds at night.	Work by Ffion Cassidy suggests that birds differ in their responses to lasers as a function of laser colour, bird type (species, sex, and age), season, and ambient light (Chapter 8).	a. Continue to explore the use of lasers, but avoid relying on them exclusively and be mindful of their potential to damage the retinas of humans and wildlife. b. Advance other visual deterrents, potentially including robots, flashing LED lights, and lifelike effigies of predators.
13. Visual deterrents are inferior to acoustic deterrents and so there is not much benefit to changing the traditional use of scarecrows.	Because birds are less likely to habituate to stimuli that invoke two or more senses, Ffion Cassidy has experimented with visual stimuli that exploit and the sensory systems and ecological contexts of birds to increase efficacy of deterrents (Chapter 8).	a. Experiment with a wider range of visual deterrents to reduce the current reliance mainly on acoustic deterrents. Visual deterrents that exploit the sensory systems of birds (e.g., UV vision) and evolved adaptations (e.g., avoidance of predators) appear to be more effective than deterrents that offer novelty alone (e.g., sirens).
14. The environmental problems associated with tailings ponds are	In addition to the graduate work above, several undergraduate students reviewed previous monitoring programs and existing literature to advance innovative	a. Expand the current emphasis on students of engineering, geology and geography as interns and research assistants to include more students and faculty in the life and environmental sciences. b. Encourage trans-disciplinary and integrative research that

complex and can only be solved by experts, such as mining engineers.	ideas about bird protection. Others conducted field or laboratory experiments to elucidate specific mechanisms of vulnerability or deterrence (Chapter 9).	fosters support simultaneously for economic, environmental and social gain. c. Acknowledge that wildlife protection in the region extends beyond migratory birds and do more to integrate wildlife mitigation on lease sites with the principles and goals of wildlife management elsewhere.
15. The problem of protecting birds in the oil sands is an issue that is most dependent on industry-based engineers.	RAPP engaged in knowledge exchange with diverse individuals from industry, government, academia, and the public to advance bird protection in the mineable oil sands (Chapter 10).	a. When practical and safe, engage the public in bird protection via monitoring of reference sites (e.g., Chapter 4) and by sharing information about monitoring and deterrence. b. Seek synergy among industry, technology-based companies, government, academia, and others to advance innovative solutions to bird protection with the potential to transfer knowledge to other contexts.
16. Improving bird deterrence is limited to professionals.	Students bring novel expertise, rigour, and dedication to the problem of bird protection with modest expense.	a. Strive to conduct more of the business of bird monitoring and protection by trainees, broadly defined, while seeking a fair exchange of safe, educational opportunities for reductions in labour costs.

To support the operational recommendations offered above, I provide below three additional recommendations that might be applied to any industry, or other human enterprise, that seeks to minimize its harm to birds as individuals and populations while contributing to the combined sustainability of society, economies, and the environment. I support these recommendations with opinions and observations of my own that integrate problems, existing evidence and potential solutions. Again, I offer them as starting points for discussion and certainly not as panaceas to the remaining challenges in bird protection.

Monitor wildlife holistically

The Oil Sands Bird Contact Monitoring Program is dedicated exclusively to monitoring birds on lease sites with a focus on waterbirds that dabble, dive or wade on process-affected ponds. Yet lease sites exert myriad effects on wildlife and many of these enhance populations of invasive, human-adapted species including gulls, ravens, coyotes, and foxes. Populations of corvids, particularly ravens, appear to be increasing rapidly.

In other contexts, these invasive species exert large effects on biodiversity and change the composition and functioning of ecological communities. The increased prevalence of scavengers also potentially obscures the results mortality searches. For example, dead birds might be scavenged by ravens before they can be detected by oil sands monitors. A similar effect has been documented in the context of window strikes in urban areas, but I know of no study that has addressed this potential in the oil sands.

Corvids and other scavenging species, including foxes, coyotes, and black bears appear to be attracted to mine sites partly for the waste products that are concentrated there. In 2011, over 60 black bears were shot or removed to prevent conflict with people. The high prevalence of scavenging, opportunistic species is likely to alter the community composition of adjacent natural areas in many ways and to influence bird protection.

Black bears were particularly common in our campsite in 2011 when wildfires destroyed much of the berry-producing habitat in the region.

Assess the efficacy of deterrent systems comprehensively

Using the standardized data provided by the standardized monitoring program, operators should identify realistic and explicit goals for bird protection, measure progress toward them, and report both successes and challenges. They should evaluate options and success with principles of systems engineering, optimization of cost-benefit ratios, and full-cost accounting of social, economic, and environmental effects. These concepts are becoming mainstream in many industrial contexts, and they could strengthen bird protection in the oil sands.

New deterrent practices should be based on rigorous evidence that is peer-reviewed and publicly-available. Because of their potential for collateral costs, decisions to adopt systems should be based on more than the promotional material of vendors. With an evidence-based approach, operators should make iterative changes to deterrent practices and use the principles of adaptive management to document the effects of those changes for further refinement. They should share this information and analyze the effects of diverse factors that apply in different combinations to the dozens of process-affected water ponds in the region.

An example of the need for comprehensive approaches to the testing of deterrents is provided by long-range acoustic devices (LRAD's), which have been installed at several mine sites. These systems can deliver sound stimuli of 156 dB, which is much louder (on the log-based scale with which sound is measured) than traditional acoustic cannons of 120-125 dB. The new devices were designed for military purposes and have not been subjects of peer-reviewed tests as bird deterrents. Because these devices are combined with long-range radar, the likelihood is high that deterrents are deployed in response to birds that are unlikely to land, increasing habituation by resident birds or birds that have travelled through the region previously. Deterrents with high sound intensity contribute to noise pollution, which has documented detrimental effects on many species, including birds, bats, fish, amphibians, reptiles, and people. It is especially damaging for songbirds, many species of which nest in the adjacent boreal forest.

Fewer birds appear to land on the process-affected water ponds with smaller floating deterrent devices, relative to those with loud devices on their perimeters. High deterrent density may be more effective than high deterrent range. Site-specific analyses could reveal the generality of these patterns.

Demonstrate excellence and transparency in bird protection

Operators should support transparency and accountability in every aspect of bird monitoring and protection for the benefits this practice could bring as public trust and social license, in addition to a more fundamental contribution to environmental stewardship. A growing proportion of society is aware of inconsistencies in the regulation of human enterprises that impact wildlife and they are demanding more stringent monitoring of industrial effects. The oil sands industry is ahead of many others in the way it monitors and protects birds and it could occupy a position of global leadership if it shared information with transparency and integrity. The industry is especially well-poised to demonstrate the benefits of collaborative, standardized approaches to monitoring that engage industry, government and academic expertise. I have found over the last three years that this process is not tidy, quick, or easy. Yet those characteristics are themselves honest signals of groups that achieve enough trust and compromise among members to support genuine innovation and improvement in practice.

With this proactive approach, the industry could lessen simplistic and dichotomous public opinion about environmental protection in the region. By sharing with the public specific goals for wildlife protection, their rationale, and progress toward them, the industry could create a much wider understanding about the complexities of integrating economic, environmental, and social sustainability. More explicit and open discussion about the problems could engage a broader cross-section of the public, many of whom could bring relevant expertise that supports innovative solutions. As part of this approach, the industry should avoid relying on distant technological solutions to eliminate tailings that forestall more immediate action.

As part of this recommendation, I encourage the industry to shed the heritage of due diligence that has encouraged investment in bird protection with benefits that are advertised or presumed, but not tested. In criminal law, due diligence can be a defense when there is undeniable evidence that a criminal act occurred if the defendant can prove that they did everything possible to prevent it from happening. This approach can encourage large expenditures that support a defense of effort, without accountability of ongoing action. Successful defenses in future may require evidence that particular deterrent systems produce net benefits to populations of birds relative to available options.

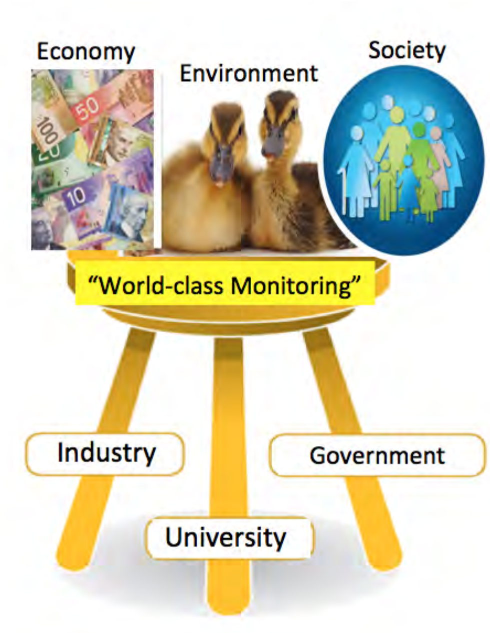
Over most of the past 40 years, the mineable oil sands industry has not shared much of the development of new deterrent systems with the public or provided peer-reviewed evidence of their efficacy. A brief study of bird deterrents I conducted in 2003 at the request of Shell Energy and with then-undergraduate student Rob Ronconi, became only the second peer-reviewed paper on that topic in the 30-year history of the mineable oil sands (the first was produced in 1980 by U of A professors Boag and Lewin). The three graduate students supported by RAPP will treble the number of M.Sc. theses produced on the issue over the past 40 years, the last one being completed in 1980 by John Gulley, who served on RAPP's advisory committee. That is a surprising rate of knowledge production for a province as well-endowed with both oil and migratory waterbirds as is Alberta. If more people could be inspired to study and improve bird protection as part of Alberta's flagship industry, it may be possible to reduce some of the current disparities in public opinion and make avian protection a source of pride for Albertans.

Mallards are among the first ducks to return each spring and make use of diverse water bodies, including roadside puddles and human-created ponds of every sort.
Photo by Dave Fairless.

Chapter 13: A Synthesis and Commentary on the RAPP Experience

With respect for the inspiring concept of a creative sentence to resolve *R v Syncrude*, and for others who might undertake the hosting of a large court-ordered research project without knowing quite what it would entail, I offer a few observations on my experience leading RAPP. I concentrate these observations on the portion of the project, Section 2, that led the development of a standardized monitoring program for bird protection. This work was very different from anything I've done before. Supporting graduate and undergraduate student projects (Section 3), accounting for the use of funds (Section 4), and synthesizing recommendations from our work (Section 5) were also challenging, but they involved more familiar tasks for which I had more experience and autonomy.

I developed a vision gradually for the collaboration that evolved with the standardized monitoring, which is now called *Oil Sands Bird Contact and Monitoring Program.* From the beginning, there was something that felt unique and very positive in the possibility that university-based research, regulatory requirements by government, and industrial innovation could be combined to generate a rate and type of change that no one actor could achieve independently. I likened our work to a 'three-legged stool' that could support the kind of monitoring needed for the industry to support the so-called 'triple bottom line' of economic, environmental, and social sustainability. I posed this vision to others in August, 2013, at the request of Sarah McLean of AESRD, to support discussion about the future of the program.



Although "world-class monitoring" is often stated as a goal in Alberta, I do not believe any one of academia, government or industry is individually able to achieve it. Academics have extensive training in relevant disciplines and access to bright, energetic graduate students, but they lack real-world experience and access to the sites most affected by industrial activity. Government has the public authority to effect change quickly, but it has little scientific capacity to identify the best solutions and diverse stakeholders to please. Industry has the site-specific expertise and capital to identify environmental problems, but it is legally bound in capitalistic societies to avoid unnecessary expenditures.

In our meetings for the monitoring program, it was often apparent that the top priorities of academic, government and industry representatives were different and opposing. It was also apparent that we academics (my students and I) were overly idealistic, eager, energetic, and cheap. Because our work was entirely supported by the court ordered funds from Alberta Justice, it was free to other government departments and industry. That made it easy for requests to increase without a clear accounting of responsibility and cost. It was also apparent that industry could not be asked to meet a set of vague and idealistic 'should-do's' based on nebulous standards that floated outside of regulatory requirements. That made for a resistant and sometimes disgruntled culture in our meetings. And, government, with looming regulatory changes that were anticipated throughout the RAPP era without being resolved, could seldom articulate specific goals for the program or standards for meeting them. That created a leadership vacuum that was apparent on many occasions.

For all of these reasons, my students and I ended up leading every aspect of developing the monitoring program and examining the data it produced. Probably no one intended that at the outset; certainly I did not! Using our reports to meet regulatory requirements for a multi-billion dollar industry resulted in some strongly opposing views among and within the three legs of the stool. Those requirements created repeated instances with intense time sensitivity that obliged long work weeks for me and other members of my team. After putting this effort into the report of the 2011 data, it was hard to learn in Fall 2012, that it was not welcomed by some committee members for the coming year. When we agreed to government's request to report on behalf of industry for a second year anyway, we unwittingly created considerable tension and generated an intense season of back-and-forth revisions to our draft reports in the spring of 2013.

Leading and reporting on the standardized monitoring program are among the hardest things I have done in my academic career and it was not the kind of work that could be delegated to technicians or graduate students. Yet the work was not always intellectually stimulating and it did not apply readily to the University's reward structure, which is based mainly on peer-reviewed publications. These realities have whittled away at the edges of my idealism about the three-legged stool. Yet it is probably because of the interdependencies and collateral costs of this unusual alliance, that the monitoring program evolved so rapidly. We accomplished a lot in the three years of RAPP; more than we could have if any of the entities had tackled the problem alone and were not bound by the priorities and constraints imposed by the others.

Time will tell whether the standardized monitoring program creates a lasting change in the way bird protection is studied and improved in the oil sands region, whether it provides an example for other industries that is a credit to the industry, government and public of Alberta, and whether it ushers more collaboration among universities, industry and government that combine rigour, realism and responsibility. If it does any of those things, I will be very satisfied; if it does them all, I will be ecstatic.

The research side of RAPP was easier, albeit not without challenges. The provision of an advisory committee with the order lent helpful perspectives and guidance throughout the project; I am very grateful to that team. Our research required unusually diverse expertise and it was a privilege to be able to learn so much about so many different topics, meeting wonderful new colleagues in the process. Relative to conventional research grants, the provision of a large amount of advance funding made it possible to explore new ideas almost as soon as we had conceived them, which, in turn, facilitated rapid growth in study designs and results.

All up, I have been honoured by the opportunity to lead RAPP, grateful for the many things I learned, and inspired by the fresh ideas and hard work of students, assistants, and colleagues in industry, government and universities. I hope the products of our research have earned the generous funding and trust offered by the authors of the creative sentence, and provide lasting value to all Albertans, to whom our natural resources—both the oil and wildlife—belong.

Appendices

Appendix A -- 2013 Tables

Data from the 2013 season of the Oil Sands Bird Contact Monitoring Program contained in 11 tables. Tables 1 – 8 are comparable to tables produced in the 2012 Report on the Regional Bird Monitoring Program; Tables 9 and 10 describe additional information.

Appendix B – 2013 Maps

Maps depicting the lease sites of the mineable oil sands region (Figure 1) and the lease sites and ponds of individual operators (Figure 2). Lease-site maps include several that are comparable to the 2012 report plus additional maps with higher resolution (1:20,000).

Appendix C – 2013 Figures

Summaries of data from the 2013 season are contained in Figures 3-15, which parallel most of the figures from the 2012 report.