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1.0 Introduction

The development of renewable energy (wind and solar) projects has the potential for both direct and indirect effects on wildlife and wildlife habitat. The role of Alberta Environment and Parks (AEP-WM) – Wildlife Branch is to ensure that renewable energy projects consider, and appropriately mitigate for these potential effects. Risk of increased bird and bat mortality is considered an important potential effect of renewable energy projects.

Post-construction bird and bat fatality monitoring programs estimate bird and bat fatality from wind turbines and solar panels. Results from these post-construction monitoring program (PCMP) surveys are used to identify species most at risk and specific periods with high fatality. This knowledge can be used to evaluate the success of mitigation measures by comparing to pre-construction data, establish protocols for operational mitigation, and inform adaptive management. Bird and bat fatality monitoring surveys are a requirement under Stage 4 of the Wildlife Directive for Alberta Wind Energy Projects (GOA 2018) and the Wildlife Directive for Alberta Solar Energy Projects (GOA 2017).

Post-construction monitoring programs (PCMPs) address regulatory requirements to understand the effect of renewable energy facilities on mortality risk for birds and bats, especially those listed under the *Species at Risk Act* (SARA), the *Migratory Birds Convention Act* (MBCA) and under provincial legislation such as the Alberta *Wildlife Act* (AWA).

The process of designing and implementing the PCMP Protocol, outlined in this document is in alignment with the Standards 100.4 (100.4.1 to 100.4.13) in the Wildlife Directive for Alberta Wind Energy Projects (GOA 2018) and Standards 100.4 (100.4.1 to 100.4.11) in the Wildlife Directive for Alberta Solar Energy Projects (GOA 2017). The survey protocol was also developed using information from:

- Recommended Protocol for Monitoring Impacts of Wind Turbines on Birds (EC 2007)
- Bat Mitigation Framework for Wind Power Development (ESRD 2013)
- The Alberta Bat Action Team's recommendations for post-construction bat surveys (Bats and Wind Turbines: Pre-siting and Pre-construction Survey Protocols [Lausen et al. 2010])
- Post-construction Wind Energy Protocol for Bats (Barclay and Baerwald 2015)
- Bats and Bat Habitats: Guidelines for Wind Power Projects (OMNR 2011a)
- Birds and Bird Habitats: Guidelines for Wind Power Projects (OMNR 2011b)
- Adaptive Management Guidelines for Saskatchewan Wind Energy Projects (SKMOE 2018)

The purpose of the PCMP Protocol is to provide wind and solar energy proponents and their consultants with a standardized protocol to design and implement a project-specific PCMP in Alberta. The protocol is intended to be intentionally broad, so it can be applied to projects of various sizes. Proponents will recognize that consultation may be required with AEP-WM to review the project-specific PCMP prior to implementation.

This PCMP Protocol (hereafter referred to as the Protocol) focuses explicitly on fatality monitoring surveys. In certain instances, depending on the conditions in the Wildlife Renewable Referral Report (hereafter referred to as the Referral Report), additional post-construction monitoring surveys may be required on a project-by-project basis. These surveys may include but are not limited to: (1) breeding bird surveys, (2) raptor nest monitoring, and (3) bat acoustic surveys. As these surveys are not consistently required for each project, they are not discussed further in this document. Design of these surveys should be discussed with AEP-WM prior to implementation.

Parameters related to the PCMPs for fatality monitoring, including the searcher efficiency and carcass persistence trials required to calculate corrected fatality estimates, are provided in Table 1 and Table 2, and further described in Section 2.0.

2.0 Post-Construction Bird and Bat Fatality Monitoring

2.1 Objective

The primary objective of the PCMP described herein is to evaluate the mortality risk to bats and birds using empirical data collected during project operation. Specifically, the PMCP should:

- Identify whether mortalities are occurring;
- Identify mortality rates, including the effect of searcher efficiency and carcass persistence on the mortality rate estimate;
- Determine what species/species groups are involved;
- Determine where mortalities are occurring and how they relate to project operations;
- Identify environmental factors that may have increased the potential of wildlife interaction with the renewable energy infrastructure (i.e., changes in weather, fog etc.) ; and
- Determine if operational mitigation is required.

The information gained from the PCMP surveys will be used to identify and scope subsequent monitoring, evaluate the success of mitigation measures, and establish protocols for operational mitigation. Should operational mitigation be required, the objective of the subsequent surveys will be to determine the success of the operational mitigation implemented.

The three components of the PCMP include:

1. Carcass searches
2. Carcass removal trials
3. Searcher efficiency trials

Further details on each of these components is provided below.

2.2 Carcass Searches

2.2.1 Survey Methods

Prior to the commencement of the carcass search, the following site conditions will be recorded at every visit:

- Date and time
- Weather conditions (e.g., wind speed and precipitation) at time of survey
- Significant weather events between the survey dates (e.g., storm events, wind warnings, high levels of precipitation)
- The search area of each transect (e.g., panel row, turbine) will be assigned a visibility classes according to Table 1 (visibility class may change between visits so must be recorded each time)
- The percent (%) of the area that is searchable (search area may vary between searches due to vegetation heights [if search areas aren't consistently mowed], presence of maintenance vehicles, etc.)

Table 1 Visibility Classes and Defining Characteristics

Visibility Class	% Vegetation Cover	Vegetation Height
Class 1 (Easy)	≥90% bare ground*	<15 cm tall
Class 2 (Moderate)	≥25 to <90% bare ground	15 – 30 cm tall
Class 3 (Difficult)	<25% bare ground	>30 cm tall

NOTE: * Bare ground would include unvegetated areas such as roads, turbine pads, or areas of ground where less than 10% of the area is vegetated.

Carcass searches typically comprise parallel transects, designed to obtain full coverage of the area to be surveyed with adjustments made in the field as required by topography or access limitations.

- For linear projects (e.g., solar panels), it is important to follow a straight line for transects, walking at a slow and steady (consistent) pace (e.g., 2-4 km/h) while making frequent reference to compass, map, and GPS as necessary.
- For non-linear projects (e.g., turbine pads), transects may follow a circular, rectangular, or square pattern depending on study site locations, arrangements, and surrounding terrain. For example, the circular pattern is recommended for searching around turbines. To aid searchers in maintaining a consistent search pattern (i.e., consistent distance between transect) a light rope affixed to the centre point of the search area (e.g., turbine) may be used. However, where obstacles may interfere with the rope system (such as in treed or shrubby habitat), a pre-determined grid system may be more effective. Regardless of the transect pattern used, the search area will need to be calculated for inclusion in the analysis (see Section 3.0).
- Search pattern must remain the same for the entire duration of the PCMP to maintain searcher consistency.
- All searches will be conducted on foot.

The time required to search each transect/study site will vary depending on surrounding habitat (e.g., open field vs forest) and individual searchers, but searchers should aim for a consistent search time amongst searchers for each transect/study site (e.g., 20 minutes) to reduce survey bias (i.e., searchers should not spend extra time looking for searcher efficiency trials).

It is critical that all existing carcasses be found (to minimize corrections on the mortality estimate); therefore, transects must be close enough together such that carcasses are not obscured from view by vegetation. Recommended spacing between parallel transects is typically 5-6 m, allowing for visual search of 2.5-3 m on either side (OMNR 2011); however, spacing will be dependent on site-specific conditions (e.g., spacing between panel rows) and must be confirmed by the survey lead prior to implementation of the PCMP. Exact spacing between transects must be defined for the project prior to the initiation of the surveys and must be maintained throughout the duration of the PCMP to ensure consistency of data collection.

Areas within the search radius with particularly tall and dense vegetation (>30 cm vegetation height with no bare ground visible) should not be searched (OMNR 2011). Searchers can use professional judgement to determine if an area with tall vegetation is searchable (e.g., tall, sparse cultivation) and the search visibility in such areas will likely be considered difficult (see example photos in Appendix A). Areas not searched must be documented on an individual site or station basis and are accounted for in calculations of mortality rate. Where possible, the development project should maintain vegetation cover at a low level in order to facilitate more accurate bird and bat mortality surveys (OMNR 2011a and OMNR 2011b). In the event that a site (e.g., turbine) has been determined to be unsearchable, an alternate site (e.g., alternate turbine) of similar search parameters (e.g., edge location) must be selected to replace the unsearchable site in order for the proponent to meet the minimum coverage defined in the Directives. It is the responsibility of the proponent to ensure they meet the minimum required coverage as surveys that are deemed inadequate by AEP-WM will not be accepted and the proponent will be required to repeat these surveys.

2.2.2 Carcass Data Collection

When a carcass is observed, the following data on the carcasses will be collected:

- Species, sex, age and reproductive stage (when possible)
- Ground cover type (where carcass is found)
- Visibility where carcass was found (easy, moderate, difficult)
- Condition (e.g., intact, scavenged, feather spots)
- Estimated number of days since death (e.g., fresh, early decomposition, moderate decomposition, advanced decomposition, complete decomposition)

- Probable cause of death (e.g., direct collision, collision with vehicles, electrocution or result of being stranded)
- Carcass size – small (e.g., bats, songbirds), medium (e.g., ducks, kestrels) or large (e.g., pelicans, hawks)
- Location (UTM coordinates, distance and direction to the nearest infrastructure (e.g., transmission tower/wind turbine/solar panel/fence))
- Descriptive features (e.g., colour, size) and photographs of carcass (refer to Appendix B for more detailed information)
- For certain species, additional information such as forearm, tragus, and ear length, whether the underside of the wing is furred, and whether a distinct keel on the calcar is visible may be required for bat identification. If white-nose syndrome (WNS) is suspected, AEP should be informed as soon as possible. Possible signs of WNS include damage to the wing and tail membrane (lesions, flaky skin, discoloured spots or scarring, multiple holes and tears to the leading edge). This should be documented with additional photos following Reichard's Wing Damage Index (Reichard and Kunz 2009).
- A unique identification number (waypoint) must be given to each observed carcass. Waypoint labels should be short but meaningful, identifying the location, date and carcass number.

Carcasses determined to be older than the search period (i.e., greater than 1 week in age) will not be included in the analysis as it is assumed the recommended fatality estimators already corrects for carcasses missed in previous searches; however, model specifics need to be confirmed within the model user guide. Carcasses judged to have been missed at least once will be collected but will be considered "incidental".

2.2.3 Required Permits

The PCMP will be conducted under a valid Permit and Collection Licence, to be acquired from AEP-WM by the consultant conducting the surveys. Further, a Canadian Wildlife Service (CWS) Scientific Migratory Bird Take Permit, for the collection and possession of dead migratory birds, will be required from Environment and Climate Change Canada (ECCC).

2.2.4 Survey Personnel

Surveys are to be designed, conducted, and supervised by an experienced wildlife biologist (as per the definition included in the *Wildlife Directive for Alberta Wind Energy Projects* and *Wildlife Directive for Alberta Solar Energy Projects*) who has previously conducted carcass searches and is familiar with the search protocol and required data collection. Searchers must have a strong understanding of the data collection requirements, including proper search techniques (described below in Sections 2.3.1 and 2.3.2), the recommended photos to take to confirm species identification (provided in Appendix A), and proper handling/storage of dead and injured wildlife.

2.2.5 Equipment Required

Surveyors should be equipped with the following equipment:

- GPS
- Datalogger or similar data collection device
- Camera
- Light rope – suggested as an aid for following transects for circular sampling sites
- Calipers – should be used for measuring carcasses and a photo documentation ruler during photo collection
- Biohazard specimen transport bags (or Ziploc bags for smaller carcasses) – all carcasses should be double bagged
- Labels – for placement on the specimen bags
- Storage receptacle – carcasses shall be stored in coolers with ice packs following collection until they can be properly stored in a freezer
- Safety equipment including but not limited to:
 - disposable gloves –worn while handling carcasses
 - leather gloves – for handling live specimens (if found; see Section 2.2.7)
 - sanitizing wipes – available for cleanup should the searcher come in contact with animal fluids
 - eye wash kit – available for cleanup should the searcher come in contact with animal fluids

- any other safety equipment identified as required by the project lead/proponent based on the project specific conditions.

2.2.6 Search Limitations

Carcass searches shall be conducted between one hour after sunrise to one hour before sunset for best light. As extreme weather conditions can have considerable effects on searcher efficiency, carcass searches should not be conducted when fresh snowfall (<12 hours or currently snowing) inhibits a clear view of the ground, in heavy rainfall, or during high winds (>50 km/h).

2.2.7 Handling of Injured Wildlife

Injured wildlife may be encountered while conducting carcass searches. All injured wildlife that would presumably require human intervention in order to survive, including those that would be stranded inside a solar facility, will be recorded as a fatality. If handling injured wildlife has been identified in the survey plan precautions will need to be taken including but not limited to:

- Wear leather gloves when handling any live animals, to protect against bites and scratches. Caution is advised when handling injured bats because they may carry the rabies virus, a potentially deadly infectious disease that can be transmitted to humans through saliva, body fluids, or tissue of infected animals (CCOHS 2018).
- In Canada, the National Advisory Committee on Immunization recommends that pre-exposure rabies vaccination should be offered as a choice to workers at possible high risk of contracting rabid animals. If bitten by a bat, visit the nearest hospital immediately (bring the bat) for a post-exposure vaccination (two shots over three days).
- If bats are found during carcass searches, take precautions to reduce the risk of being bitten. Handle bats with leather gloves (bats typically cannot bite through leather) and place disposable gloves over leather gloves to prevent contamination of the leather.
- If you suspect a bat of having rabies, make a note of the bat (especially so it does not get counted again on a future visit) and try to move it out of the sampling area with a long instrument that prevents direct contact between you and the bat. Requirement to report and/or dispose of must be determined through consultation with the client and AEP-WM.
- Normally, injured animals should be taken to the local AEP-WM office or a rehabilitation center, following proper operational, health and safety requirements specific to the surveyor's employer.

Additional disinfection procedures should also be followed for any piece of equipment that comes in contact with a bat where WNS is suspected (USFWS 2009, WNS 2018). Suspected WNS bats should be reported immediately to AEP-WM (with client approval) and should not be used for future searcher efficiency or scavenger removal trials.

Where survey plans identify that surveyors will not be handling injured wildlife the proponent is responsible for identifying a plan to appropriately collect, care and relocate/release/euthanize injured wildlife. This plan must be reviewed and approved through AEP-WM Renewable Review Process and Permitting Process.

2.2.8 Additional Requirements

Additional requirements for post-construction casualty monitoring at the project include:

- Non-species at risk carcasses found during fatality monitoring will be collected and stored in a freezer and used in carcass removal or observer efficiency trials, assuming they are in reasonable condition (e.g., intact, fresh).
- Following completion of the surveys, all carcasses will be submitted to AEP-Wildlife Lab (attn.: Wildlife Disease Specialist, O.S. Longman Building, Seventh Floor, 6909-116 Street, Edmonton, Alberta, T6H 4P2).
- All site personnel are to report any observed carcasses to the Site Supervisor to ensure all fatalities are reported to AEP-WM and to assist in the identification of large mortality events, should they occur.
- Carcasses observed by non-survey site personnel (e.g., maintenance workers) should be left in place to prevent bias with searches or trials.
- Carcasses found incidentally (i.e., outside the search area) while traveling within the project footprint will be collected and recorded; however, will be excluded from the corrected fatality estimate.

Observations of bat or bird fatality will be recorded, and carcasses collected regardless of whether they are thought to be a result of turbine/panel collision or other sources (e.g., vehicle collision).

2.3 Carcass Removal Trials

Carcass removal trials will be conducted to correct for carcasses that may be missed during carcass searches due to scavenger removal, carcass decomposition or other environmental factors (e.g., wind blowing the carcass out of the search area). The level of carcass scavenging must be determined through carcass removal trials each year, as it varies from one project site to another depending on the scavenger community and abundance. The average carcass persistence time is a factor in determining the estimated bat or bird fatality rates.

Carcass removal trials are conducted by:

- Placing a known number (20 minimum) of carcasses per season throughout the Project.
- The number of carcasses may vary between projects; however, justification to go below the minimum amount of 20 per season must be approved by AEP-WM prior to commencement of the PCMP.
- No more than two carcasses should be placed in a given area [e.g., at a single turbine]) at a given time.
- Carcasses should be placed across the various habitat types (e.g., cultivation, grassland, etc., if applicable) within the project area, while also incorporating the various vegetation structures represented in the surveys to cover all visibility classes (easy, moderate and difficult).
- Carcasses should be placed strategically throughout the project so as to avoid congestion of trial carcasses in a given area. This may require placement of carcasses outside of search areas (e.g., at a non-search turbine, on access roads).
- As a minimum, carcasses will be checked on days 1, 2, 3, 4, 7, 14 and 28 to determine how long before carcasses are scavenged or sufficiently decomposed. Alternative schedules may be permitted if appropriate rationale is provided. The use of remote cameras is permitted, however caution must be taken to ensure the presence of the camera does not unnaturally alter the behaviours of scavengers.
- A variety of carcass sizes may be used; however, if using size as an interaction (variable) proponents would need to ensure an adequate number of carcasses per size is used (minimum 10 carcasses/size class is recommended) which may result in higher numbers of trial carcasses required.
- For wind projects, bat carcasses should be used for at least one third of the carcass persistence trials and at least 50% where the pre-construction surveys showed high levels of bat activity and lower risk of bird mortality.

- Trials using other small mammal or bird carcasses (e.g., mice, brown chicks) may also be used when bird and bat carcasses are not available. Surrogates used should attempt to imitate the size, colouration and scavenger diet of the species most susceptible to fatality at the facility.
- Carcasses used should be as fresh as possible as decomposed carcasses are less attractive to scavengers. If frozen carcasses are used, they shall be thawed prior to beginning the trials
- All carcasses placed shall have an associated carcass ID number to properly keep track of which carcasses are lost during the trials to ensure proper reporting of carcasses submitted to AEP-WM. Any mark placed on the carcass to identify it as a trial carcass must be discreet.
- No species at risk shall be used as carcasses for trials
- Carcasses should be placed using rubber (or other scent-free) gloves to avoid leaving a human scent that might bias trial results by attracting scavengers.
- Carcass removal trials are to be conducted separately from the searcher efficiency trials.
- Carcass removal trials must be conducted once per season (i.e., one trial in spring, one trial in summer, and one trial in fall) for each year of the PCMP. Season dates must be defined within the PCMP provided to AEP-WM and must be consistent for the duration of the PCMP.

2.4 Searcher Efficiency Trials

Searcher efficiency trials are conducted because efficiency can vary considerably among searchers and may influence estimates of total bird and bat mortality. Searcher efficiency trials involve the distribution of marked carcasses within the search area without searchers being aware of the locations. The frequency with which carcasses are detected is used to adjust survey results to reflect the efficiency of carcass detection by each searcher.

Searcher efficiency can vary considerably for each searcher and from one site to another (varying by vegetation cover, terrain and season). As such, trials will be conducted as part of post-construction monitoring in each year of monitoring, at representative habitat sites throughout the project (i.e., all habitat types within the project must be sampled), and for each person involved in carcasses searches during the year.

Below are some additional considerations for conducting searcher efficiency trials:

- Trials are conducted by placing a known number of marked carcasses (minimum 20 per searcher per season) be placed within the study area by an independent “tester” prior to the regularly scheduled carcass searcher

- A unique ID should be given to each carcass set out. Waypoint labels should be short but meaningful, identifying the season, location in study area, and carcass identifier.
- Trial carcasses should be placed randomly within the search area (no more than 2 carcasses per search area (e.g., turbine) per search day, with the location recorded so that they can be retrieved if they cannot be found.
- Carcass locations should be placed in a variety of vegetation structures to cover all visibility classes (easy, moderate and difficult). It is recommended to get a minimum of 10 carcasses per visibility class to be able to test interactions (variables) between classes.
- A variety of carcass sizes may be used; however, if using size as an interaction (comparison) proponents would need to ensure an adequate number of carcasses per size is used (minimum 10 carcasses/size class is recommended) which may result in higher numbers of trial carcasses required.
- Searchers survey the search area as if they were conducting a regular carcass search. At the end of the day the “tester” compares the number of carcasses found to the number of carcasses placed and collects any remaining carcasses that were not found by the search.
- If a carcass was not found by the observer and is missing when the “tester” returns, it is deemed scavenged and does not count against a searcher’s efficiency. Another trial carcass will need to be placed so each searcher meets the minimum amount of trials.
- To the extent possible, bat carcasses will be used for at least one third of the carcass removal trials conducted for wind projects, and bird carcasses will comprise the remaining trial carcasses. Trials using other small brown mammal or bird carcasses (e.g., mice, brown chicks) may also be used when bird and bat carcasses are not available.
- Searcher efficiency trials are to be conducted separately from the Carcass removal trials.

2.5 Summary

Details of the PCMP survey standards for fatality monitoring for wind and solar energy projects are summarized in Table 2 and Table 3, respectively.

Table 2. Summary of Parameters for Wind Energy Project Post-Construction Fatality Monitoring Surveys

Monitoring Component	Monitoring Parameter	Value	Comments
Carcass searches	Duration (years)	3 (minimum)	Surveys will be conducted between March 1 to October 31 each year. If mitigation actions are required based on the results of the monitoring, the proponent must conduct an additional two years of mortality surveys to assess the success of the mitigation.
	Sample Size (number of turbines)	20 turbines or 33% (whichever is greater)	Search turbines ¹ should be selected through a stratified random sample which allows for: <ul style="list-style-type: none"> Adequate coverage throughout the study area (e.g., all quadrants in the project include search turbines) Representation of all habitat types A mix of edge and internal turbines The same turbines must be sampled for the duration of the PCMP. Should a turbine not be searchable (e.g., turbine is no longer in service), a turbine with similar parameters will be selected.
	Search Area (radius; m)	Half the maximum height of the turbine (measured from ground to blade tip) or a radius of 50 m (whichever is greater)	To the extent possible the search area will be maintained, however as searchers are not always able to search the entire radius (due to presence of thick or tall vegetation, steep slopes, active cultivation, etc.), the actual area searched during each visit will need to be calculated. It is the proponent's responsibility to ensure adequate coverage of the search area and align with the requirements of the Directive and any associated requirements of the model being used. A description of areas deemed to be unsearchable will be provided in the annual fatality report.
	Transect Spacing (m)	5-7 m	Equally spaced transects (e.g., circular transects spaced 5-7 m apart) will be walked by searchers at a consistent pace.
	Frequency (search period)	Weekly	Surveys must be conducted weekly at each turbine site selected for monitoring
	Number of Weeks (survey period)	~35 (based on March 1 to October 31)	Survey periods shall encompass the spring and fall migration seasons and the summer breeding season

¹ Additional turbines may need to be searched depending on the alternative mitigation and commitments made by the proponent as outlined in the AEP-WM Renewable Referral Report.

Carcass Removal Trials	Number of trials	3	Three dedicated trials will be conducted per year; one per season (spring, summer and fall). Dates must be defined in the PCMP provided to AEP-WM (e.g., spring season encompasses March 1 to May 15, summer season encompasses May 16 to August 15, and fall season encompasses August 16 to October 31). Carcass removal trails are to be conducted separately from the searcher efficiency trials.
	Number of carcasses	20 minimum	Carcasses will be placed randomly throughout the study area to adequately cover visibility classes present (e.g., easy, moderate, difficult; see Table 1). Each carcass will be georeferenced with a GPS. Trial carcasses will be discreetly marked (e.g., clipping of ear, wing, leg, fur, etc.) with a unique identification so that they can be verified as a trial carcass by the tester. Carcasses will not be anchored to the ground (e.g., with rocks, string or other means).
	Duration	Equal to the search period, up to 2 weeks	Checked daily until gone, or up to two weeks (14 Days)
Searcher Efficiency Trials	Number of trials	3	3 dedicated trials per searcher will be conducted per year; one per season. Dates for each season should be consistent with the carcass persistence trials. Additional trials will be required if staff changes occur (all searchers must meet the minimum of 20 carcasses per season they are searching). Searcher efficiency trials are to be conducted separately from the Carcass removal trials.
	Number of carcasses	20 minimum	Trials carcasses will be placed randomly by an independent tester within the search area to adequately test the visibility classes present (e.g., easy, moderate, difficult; see Table 1). No more than 2 carcasses to be placed at a turbine at a time. Carcasses will not be anchored to the ground (e.g., with rocks, string, or other means); thus, a potential for trials to be scavenged exist, which will require additional trials to be placed to meet the minimum, if scavenging occurs. Trial carcasses will be discreetly marked (e.g., clipping of ear, wing, leg, fur, etc.) with a unique identification so that they can be verified as a trial carcass by the searcher.

Table 3. Summary of Parameters for Solar Project Post-Construction Fatality Monitoring Surveys

Monitoring Component	Monitoring Parameter	Value	Comments
Carcass searches	Duration (years)	3 (minimum)	Surveys will be conducted between March 1 and November 15 for projects within the Grassland and Parkland Natural Regions (GNR and PNR). Surveys will be conducted between April 1 and September 30 within the Boreal and Rocky Mountain Natural Regions (BNR and RMNR). If mitigation actions are required based on the results of the monitoring, the proponent must conduct an additional two years of mortality surveys to assess the success of the mitigation.
	Sample Size (number of panels)	Project <10 MW = 100% of Project Projects >10 MW = 33% of Project	The project consists of the infrastructure (panel rows) as well as the perimeter fence. To meet the required sample size proponents must include both in their search area. For projects greater than 10 MW selected panel rows and fence lines will be walked for the entire length.
	Transect Spacing (m)	Panel row width	Based on row width between the panels; rows and fence-lines will be walked by observers at a pace of approximately 2.4 km/h.
	Frequency (search period)	Weekly in the spring and fall migration periods Bi-weekly (once every two weeks) in the summer breeding period	Surveys will be conducted weekly during the migration periods and once every two weeks during the summer. Spring migration: March 1 to April 15 (GNR and PNR) or April 1 to May 30 (BNR and RMNR). Summer breeding: May 16 to August 14 (GNR and PNR) or June 1 to July 31 (BNR and RMNR). Fall migration: August 16 to November 15 (GNR and PNR) or August 1 to September 30 (BNR and RMNR).
	Number of Weeks (survey period)	~37 (based on March 1 to November 15)	Survey periods to encompass the spring and fall migration seasons and the summer breeding season, depending on Natural Region
Carcass Removal Trials	Number of trials	3	3 dedicated trials will be conducted per year; one per season (spring, summer and fall – timing windows defined above). Carcass removal trials are to be conducted separately from the searcher efficiency trials.
	Number of carcasses	20 minimum	Carcasses will be placed randomly throughout the study area to adequately cover visibility classes present (e.g., easy, moderate, difficult; see Table 1). Each carcass will be georeferenced with a GPS. Trial carcasses will be discreetly marked (e.g., clipping of ear, wing, leg, fur, etc.) with a unique identification so that they can be verified as a trial carcass by the tester

			Carcasses will not be anchored to the ground (e.g., with rocks, string or other means)
	Duration	Equal to the search period, up to 2 weeks	Checked daily until gone, or up to 2 weeks
Searcher Efficiency Trials	Number of trials	3	3 dedicated trials per searcher will be conducted per year; one per season (spring, summer and fall – timing windows defined above). Additional trials will be required if staff changes occur (all searchers must meet the minimum of 20 carcasses per season they are searching). Searcher efficiency trials are to be conducted separately from the Carcass removal trials.
	Number of carcasses	20 minimum	Trial carcasses will be placed randomly within the project to adequately test the visibility classes present (e.g., easy, moderate, difficult; see Table 1). Carcasses will not be anchored to the ground (e.g., with rocks, string, or other means); thus, a potential for trials to be scavenged exist, which will require additional trials to be placed to meet the minimum, if scavenging occurs. Trial carcasses will be discreetly marked (e.g., clipping of ear, wing, leg, fur, etc.) with a unique identification so that they can be verified as a trial carcass by the searcher.

3.0 Data Analysis

3.1 Fatality Estimates

All fatality estimates will be calculated using a fatality estimator approved by AEP-WM, such as the Huso (2011) estimator, GenEst (Simonis et al. 2018), or an acceptable alternative (GOA 2017, GOA 2018). The selected fatality estimator should be stated within the PCMP for approval by AEP-WM. However, the estimator or statistical method may be substituted at the time of analysis, concordant with the field methods used, should an alternate analysis be determined to provide a more accurate or effective fatality estimate. If the fatality estimator is substituted, AEP-WM must be consulted and provided with rationale for the deviation from the approved PCMP.

The proponent needs to ensure they are meeting the requirements of the model they have selected and provide the required details in order to enable AEP-WM's assessment.

It is the responsibility of the proponent to ensure data analysis is conducted by personnel experienced with the fatality estimator software. Unfamiliarity with the software listed within this Protocol is not a valid reason for using models not accepted by AEP-WM, and reports providing calculations from unapproved models may be rejected by AEP-WM.

All approved fatality estimators need to consider relevant updates or revisions (e.g., bleed-through and Huso et al. [2012], as well as have a 90% confidence interval using bootstrapping [Manly 1997]). The Huso (2011) estimator is commonly used for calculating fatality estimates because it uses a binomial model to estimate the probability of carcass detection. The binomial carcass detection model could be used to calculate fatalities at project linear features (e.g. panels, fences, overhead lines) or during conventional transects (e.g., at search turbines). It is the responsibility of the proponent to ensure the fatality estimates are calculated using the most recent version of the fatality estimator chosen for the PCMP.

Bootstrapping is a computer simulation technique that is useful for calculating variances and confidence intervals for parameter estimates when distributional assumptions might not be met. Bootstrapping is used to generate estimates of variance for each variable, including searcher efficiency, probability of a carcass persisting to the next search, adjusted search interval and observed fatalities from a sample of the facility. From these bootstrap samples, the probability of available and detected carcasses will be calculated and applied to the bootstrapped observed fatalities. The lower 5th and upper 95th percentiles of the bootstrap replicates provide estimates of the lower limit and upper limit of an approximate 90% confidence interval (CI) on all estimates. Proponents must confirm within the model's user guide the adequate number of iterations and provide that information in the annual report submitted to AEP-WM.

Fatality data should be combined into one dataset and include the following parameters:

- Location (e.g., turbine number, panel transect)
- Density-weighted proportion (DWP) area searched as required
- Date found
- Date last searched
- Visibility class
- Species found
- Migratory vs. non-migratory (bats only)
- Age
- Sex
- Body condition

Because carcasses can fall outside the search area, current fatality estimator models (Huso [2011] and GenEst [Simonis et al. 2018]) factor in DWP, which is the proportion of carcasses expected to land within the search area, based on the size of the carcasses (Hull and Muir 2010; Huso et al. 2012; Simonis et al. 2018). Fatality estimates should be run using both the default DWP of 1, and the calculated DWP to determine the sensitivity of this value for accurate estimates.

3.2 Carcass Removal

Carcass removal data for all trials should be compiled into a single dataset with the following parameters:

- Location
- Date placed
- Size class
- Visibility class
- Species used
- Time in days when the carcass was known to be present (e.g., left censor time)
- Time in days when the carcass was first known to be absent (e.g., right censor time)
- Event indicator - indicating the response variable for the selected model. Labels may vary between models but will typically include information about if the carcass was still present when the trial ended and when the date the carcass was observed to no longer be present (e.g., first time absent). It is further recommended to provide information on how long the carcass remained intact (i.e., keep a record of deterioration).

3.3 Searcher Efficiency

Searcher efficiency data for all trials should be compiled into one dataset with the following parameters:

- Location
- Date placed
- Size class
- Visibility class

- Species used
- Searcher
- Response variable – indicator of whether the test carcass was found by the searcher or not (e.g., Found = 1, Not Found = 0). Refer to the model’s user guide for the applicable response variable.

4.0 Reporting

Raw data collected as a result of the PCMP will be submitted to AEP-WM using the appropriate Fish and Wildlife Management Information System (FWMIS) loadform. All loadforms will be submitted with the annual report to AEP-WM. The annual post-construction monitoring reports (example Table of Contents provided in Appendix C) will be prepared and submitted by January 31 of the following year, and will include the following information as identified in the Directives (GOA 2017, GOA 2018):

- Methods and rationale for any deviations from this guidance document. This may require prior review and acceptance by AEP-WM to ensure the survey meets the requirements of AEP-WM Policy (Directive)
- A figure showing the search area (e.g., panels or turbines included in the PCMP) and the location of the carcasses found
- Results of the carcass removal trials and searcher efficiency trials, and an explanation of how the results affected the estimated mortality results
- Calculation of the carcass removal and observer efficiency using the Huso (2011) or GenEst (2018) estimators, or accepted alternative fatality estimator approved by AEP-WM, and a detailed explanation of the results including but not limited to a description of model used and parameters selected (e.g., predictor variables such as carcass visibility)
- The uncorrected fatality rate for birds and bats expressed as the number of mortalities/MW/year and the number of mortalities/turbine/year (wind projects only)
- The corrected fatality rate (using the approved fatality estimator) for birds and bats expressed as the number of mortalities/MW/year and the number of mortalities/turbine/year (wind projects only)
- A summary of species killed

- A comparison of the estimated fatality rates from pre- construction surveys and the fatality rates from the post-construction surveys
- Fatality monitoring data per monitoring event per search area including:
 - Location (e.g., turbine number);
 - Date and time the search is conducted;
 - Weather conditions, including wind strength and direction;
 - Vegetation surrounding the search area;
 - Searcher identity (consistent name or number for each observer); and
 - For each individual detected record:
 - o Location (UTM coordinates);
 - o Species;
 - o Sex;
 - o Age class (if apparent);
 - o State of decomposition; and
 - o Apparent injuries and signs of scavenging.

Akaike Information Criterion (AIC) is used to determine the best fitting models for carcass removal and searcher efficiency estimates. AIC provides a statistical method of model selection by measuring the relative quality of each candidate model tested based on their parameters (Schwarz 2011). The model with the lowest AIC value represents the best-supported model that includes the most important explanatory variable(s) such as season or visibility class; a brief summary of the selected model must also be included in the annual report to AEP-WM.

5.0 Worker Training and Monitoring

It is recommended that a site-specific worker environmental training plan will be developed by the Proponent for all personnel working on site and implemented throughout a project's operating life. All employees and contractors working in the field shall be required to attend the environmental training session prior to working on site. This training shall include information regarding the sensitive biological resources, restrictions, protection measures (including minimizing light pollution), individual responsibilities associated with the project, and the consequences of non-compliance.

Of particular importance is continued monitoring of the site during operation by workers, especially during years when fatality monitoring programs are not executed. Well trained workers are an excellent source of local information to record any fatality events, particularly for species at risk. Personnel should be trained to identify and report fatality events.

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Appendix A: Visibility Class: Photographic Examples of Visibility Class Variations



Photo A-1 General habitat within search area. Bare ground – searchable. Easy visibility class.



Photo A-2 General habitat within search area. Short vegetation (5-15 cm) – searchable. Easy visibility class.



Photo A-3 Short vegetation (5-15 cm) and sparse - searchable. Easy visibility class.



Photo A-4 Tall vegetation (15-30 cm) - searchable. Moderate visibility class.



Photo A-5 Tall vegetation (10-20 cm) - searchable. Moderate visibility class.



Photo A-6 Mowed vegetation - searchable. Moderate visibility class.



Photo A-7 Tall vegetation (>30 cm) but sparse – searchable. Difficult visibility class.



Photo A-8 Tall vegetation (>30 cm) but sparse – searchable. Difficult visibility class.



Photo A-9 Tall vegetation (>30 cm) and dense – not searchable.



Photo A-10 Tall vegetation (>30 cm) and dense – not searchable.

Appendix B: Bird and Bat Features to Photograph

B.1 Bird Features to Photograph

At a minimum, take 2-3 photos of each carcass from different angles so all field marks are captured. Depending on the bird and the state of the carcass, additional photos may need to be taken to properly ID the carcass. For most bird carcasses, the standard set of photographs recommended for ID is:

- Body Side View (Photo B-1), including head and wing side profiles
- Face/Head (Photo B-2)
- Back (Photo B-3), including back, tail and wing features
- Wing (Photo B-4), including the entire wing if possible
- Tail (Photo B-5), including shape and pattern

Some species have additional features that vary by age and sex, or may be of interest for other reasons. These may include the underwing, undertail, feet, etc. Searchers should be familiar with these features.



Photo B-1 **Side Profile**



Photo B-2 Face and Chest Profile



Photo B-3 Back and wing profile



Photo B-4 **Wing profile of passerine bird**



Photo B-5 **Tail of Passerine bird**

B.2 Bat Features to Photograph

At a minimum, take 2-3 photos of each carcass from different angles so all field marks are captured. Depending on the bat and the state of the carcass, more photos may need to be taken of field markings to properly ID the carcass. This is especially true for the *Myotis* species. For most bat carcasses, the standard set of photographs recommended for ID is:

- Forearm length (Photo B-6)
- Tragus length (Photo B-7)
- Calcar (Photo B-8)
- Finger joints (Photo B-9)
- Underwing (Photo B-10)

Other features that can be measured include the tibia (Photo B-11) and wingspan.



Photo B-6 Measuring the Forearm



Photo B-7 Measuring the Tragus



Photo B-8 Calcar without prominent keel

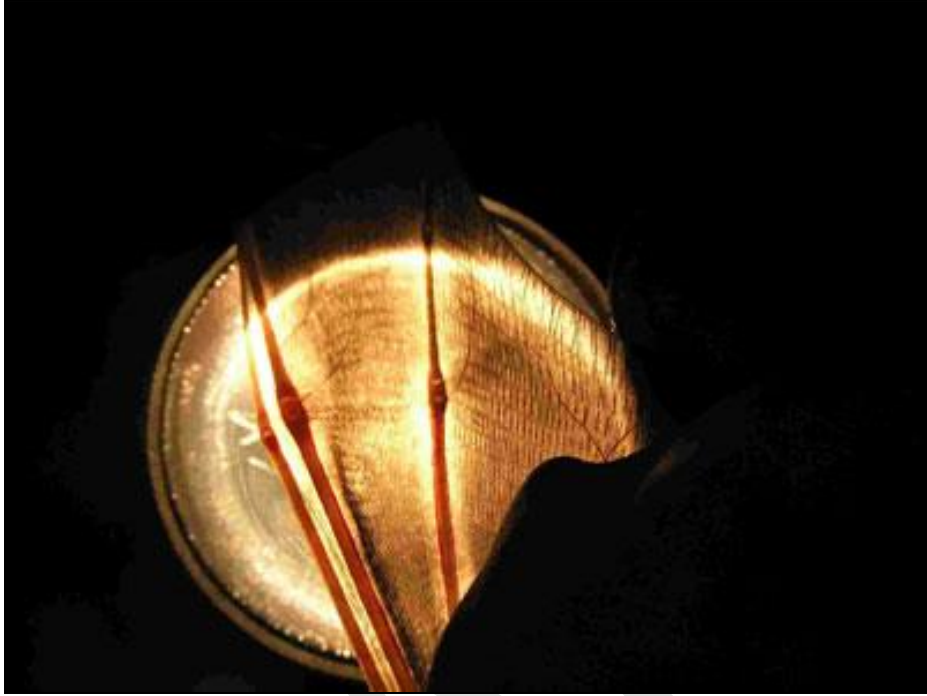


Photo B-9 **Finger joint of a juvenile bat**



Photo B-10 **Underwing**



Photo B-11 Measuring the Tibia

Appendix C: Recommended Table of Contents

- 1.0 Introduction
 - 1.1 Background and Project Overview
 - 1.2 Regulatory Context
 - 1.3 Purpose
- 2.0 Methods
 - 2.1 Field Methods
 - 2.1.1 Carcass Searches
 - 2.1.2 Carcass Persistence Trials
 - 2.1.3 Searcher Efficiency Trials
 - 2.1.4 Incidental Fatalities
 - 2.2 Data Analysis and Correction Factors
 - 2.2.1 Fatality Estimates
 - 2.2.2 Carcass Persistence
 - 2.2.3 Searcher Efficiency
 - 2.2.4 Turbine Ground Cover and Proportion of Area Searched
- 3.0 Results
 - 3.1 Corrected Fatality Estimates and Found Fatalities
 - 3.1.1 Found Fatalities

Table – Summary of Systematically Found Fatalities within the Study Area

Date	Species	Turbine	Easting	Northing	Distance from Turbine (m)
					e.g., 25
					e.g., 20
Average					e.g., 23

Table – Summary of Incidentally Found Fatalities within the Study Area

Date	Species	Closet Turbine	General Habitat	Comments
				e.g., found by maintenance crews
				e.g., found on road

3.1.2 Corrected Fatality Estimate

Table – Fatality Rate Confidence Intervals

Fatality Rate/Turbine/Year	Confidence Interval (95%)	Fatality Total	Confidence Interval (95%)
Total Bats			
Migratory Bats			
Non-migratory Bats			

3.1.3 Correction Factors

3.1.3.1 Carcass Removal

Table – Seasonal Carcass Removal Rates

Season	Carcass Persistence Time (days)	Persistence Time 95% CI	Carcasses persisting after 7 days (%)	95% CI
Spring				
Summer				
Fall				

3.1.3.2 Searcher Efficiency

Table – Searcher Efficiency Rates Per Season and Per Visibility Class

Season	Number of Searchers	Average Searcher Efficiency	95% CI
Spring	e.g., Two		
Summer	e.g., Four		
Fall	e.g., Four		

Visibility Class	Number of Searchers	Average Searcher Efficiency	95% CI
Easy	e.g., Two		
Moderate	e.g., Four		
Difficult	e.g., Four		

3.1.3.3 Turbine Ground Cover and Proportion of Area Searched

3.2 Distribution of Fatalities

Table – Fatalities Found in the Study Area

Location (e.g., Turbine)	Number of Found Fatalities	Species	Location in Study Area	General Habitat
Turbine X	e.g., 6	e.g., 3 LACI; 3 LANO	e.g., southwest	e.g., Cropland
Turbine X	e.g., 2	e.g., 1 LANO; 1 LABO	e.g., northeast	e.g., Grassland

4.0 Discussion

4.1 Fatality Overview

4.2 Operation Mitigation

5.0 Summary and Conclusion

6.0 Literature Cited

Appendix A – Fatality Rate Corrections and Confidence Intervals for Fatalities (raw data tables)

Appendix B – Site Photos (inclusion of photos of sites deemed too “difficult” to search, etc.)

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Appendix D: Abbreviations

AEP - WM	Alberta Environment and Parks – Wildlife Management
AIC	Akaike Information Criterion
AWA	<i>Alberta Wildlife Act</i>
CI	Confidence Interval
CWS	Canadian Wildlife Service
DWP	Density Weighted Proportion
ECCC	Environment and Climate Change Canada
ESRD	(Alberta) Environment and Sustainable Resource Development
FWMIS	Fish and Wildlife Management Information System
GOA	Government of Alberta
MBCA	<i>Migratory Birds Convention Act</i>
MW	Megawatt
OMNR	Ontario Ministry of Natural Resources
PCMP	Post-construction Monitoring Program
SARA	<i>Species at Risk Act</i>
SKMOE	Saskatchewan Ministry of Environment
WNS	White-nose Syndrome

Appendix E: Glossary

Akaike Information Criterion (AIC)	Statistical method of model selection by measuring the relative quality of each candidate model tested based on their parameters. The model with the lowest AIC number represents the best model explaining variance in the dataset.
Correction Factors	Due to imperfect detection, carcass counts need to be adjusted based on estimated detection probabilities. Detection probabilities are estimated through searcher efficiency trials and scavenger/carcass persistence trials.
Covariate	Variable that is used in the fatality model that may have an effect on the outcome, e.g., season and visibility class.
Confidence Interval (CI)	A statistical estimate of a range or interval of unknown population parameters with upper and lower bounds, that is likely to include the true population mean. Using a 95% CI, we state that we are 95% confident that the interval calculated contains the true mean.
Density-weighted Proportion (DWP)	The proportion of the carcass density that is estimated to be within the searched area under the turbine, taking into account differences in carcass density at different distances from the turbine.
Incidental Fatality	Any found carcass made outside the systematic survey protocol (i.e., not at a search turbine or a carcass determined to be outside the search interval)
Search Interval	The time between when searches are conducted at turbines, e.g., weekly.
Systematic Fatality	Any fatality found during the specific carcass survey and within the defined search period

Visibility Class

Represents the vegetation density in which the carcass was found. Classes include easy, moderate, and difficult

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Original signed by: _____

Date:

Name of approver

Program/branch name

Environment and Parks

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