



Environmental Assessment

2026

Marine Licensing Application



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1. Applicable and Reference Documents

ID	Definition
AD1	Marine (Scotland) Act 2010
AD2	Scotland's National Marine Plan (2015)
RD1	Machrihanish Navigation Risk Assessment, Project: Lowlander Pathfinder (EXO_SSL_NRA)
RD2	Best Practicable Environmental Option, Project Lowlander Pathfinder (EXO_SSL_BPEO)

2. Introduction

This Environmental Assessment (EA) has been prepared in support of the Marine Licence application for the proposed Lowlander Pathfinder launch at Machrihanish Airbase. The assessment considers the potential environmental effects associated with the launch, vehicle descent, splashdown, recovery activities and the unlikely scenario of unrecovered debris.

Lowlander Pathfinder is a small-scale demonstrator mission intended to validate launch, tracking and recovery systems for future operations. The proposed activity comprises a single launch event, with the vehicle launched westward from Machrihanish Airbase before descending under parachute recovery systems and being recovered following splashdown offshore.

The assessment focuses on environmental receptors with the greatest potential to be affected by the proposed activity, including the Machrihanish Dunes Site of Special Scientific Interest (SSSI), local avifauna, the Sound of Gigha Special Protection Area (SPA), atmospheric conditions and the marine environment. The assessment considers the nature, scale and duration of potential impact pathways and evaluates whether significant adverse environmental effects are likely to occur.

The environmental implications of unrecovered debris are considered at a proportionate level within this assessment, with further detail provided within the accompanying Best Practicable Environmental Option (BPEO) assessment.



3. Machrihanish Dunes SSSI

Machrihanish Dunes Site of Special Scientific Interest (SSSI) is located on the west coast of the Kintyre Peninsula, Argyll and Bute, immediately adjacent to the proposed launch location at Machrihanish Airbase. The SSSI extends for approximately 5 km along the coastline between Machrihanish and Westport and covers an area of approximately 293 ha. The site comprises the largest sand dune system on mainland Argyll and is designated for its extensive dune habitats and associated coastal flora.

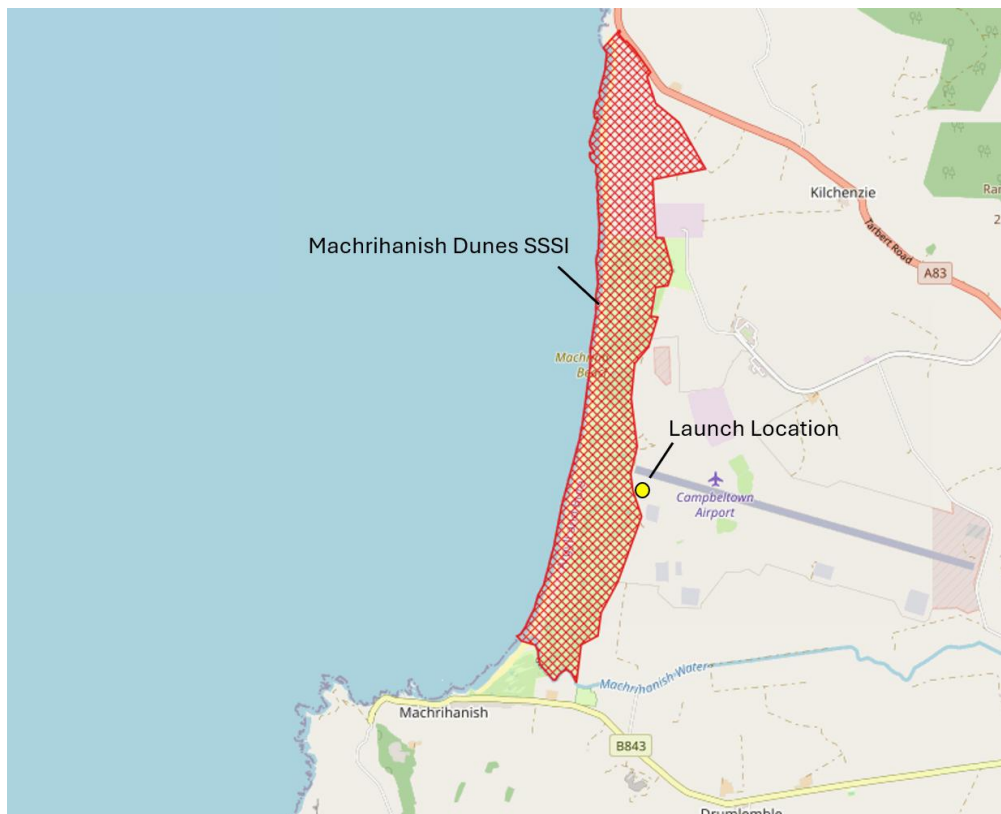


Figure 1 - Machrihanish Dunes SSSI

As shown in Figure 1 above, the SSSI lies immediately west of the proposed launch site. The launch will take place from the western edge of the airfield, with the vehicle following a westward trajectory over Machrihanish Bay. As a result, part of the flight path passes over the designated site before proceeding offshore. In addition, trajectory modelling indicates that, under certain recovery scenarios, there is a low-probability potential for vehicle touchdown within or adjacent to the SSSI.

Given its proximity to the launch location and flight corridor, Machrihanish Dunes SSSI is considered the primary designated terrestrial receptor for the proposed activity and has therefore been assessed within this Environmental Assessment.



3.1. Probability of Vehicle Touchdown within Machrihanish Dunes SSSI

A Monte Carlo trajectory analysis was undertaken as part of the Navigation Risk Assessment (EXO_SSL_NRA) to evaluate the potential landing locations of the vehicle under a range of recovery scenarios. Using the trajectory outputs generated for the assessment, a GIS-based analysis was undertaken to determine the proportion of simulated landing points occurring within the Machrihanish Dunes SSSI boundary.

The analysis was based on the trajectory simulations presented within EXO_SSL_NRA using the modelled launch heading and assumed wind conditions of approximately 14 mph.

Scenario	Touchdowns within SSSI	Total Simulations	Probability
Nominal Recovery	203	5,000	4.1%
Main at Apogee	2,954	5,000	59.1%
Drogue Only	114	5,000	2.3%
Ballistic	0	5,000	0.0%

The analysis indicates that vehicle touchdown within the SSSI is not predicted under the ballistic scenario and remains relatively infrequent under the nominal and drogue-only recovery scenarios. Under the nominal recovery scenario, the vehicle descends beneath the main parachute at approximately **6 m/s**, resulting in a 4.1% probability of touchdown within the SSSI. Under the drogue-only scenario, the increased descent rate of approximately **16 m/s** reduces drift time and results in a 2.3% probability. The highest proportion of touchdowns occurs under the main-at-apogee scenario, where deployment of the main parachute immediately after apogee results in an extended descent period and increased wind drift, producing a touchdown probability of 59.1%. Under the ballistic scenario, where no parachute deployment occurs and the vehicle descends rapidly, no simulated touchdown locations occurred within the SSSI boundary. These results are based on the modelled launch heading and assumed wind conditions presented within EXO_SSL_NRA and should therefore be considered indicative of the simulated conditions rather than predictive of actual touchdown locations on the day of launch.

3.2. Flora

3.2.1. Baseline Flora and Vegetation Communities

Machrihanish Dunes SSSI supports a diverse range of dune habitats representative of a well-developed coastal dune system. The vegetation communities present within the site reflect a transition from the exposed shoreline through to more stable inland dune habitats. NatureScot



identifies a sequence of habitats including strandline vegetation, embryo dunes, foredunes, semi-fixed dunes, fixed dune grassland and seasonally wet dune slacks.

Vegetation associated with the upper beach and strandline includes species adapted to salt spray and periodic inundation, including sea rocket (*Cakile maritima*), frosted orache (*Atriplex laciniata*) and sand couch (*Elymus junceus*). Further inland, foredune habitats are dominated by marram grass (*Ammophila arenaria*), which plays an important role in dune formation and stabilisation. These habitats transition into extensive fixed dune grassland supporting a diverse assemblage of herbaceous plant species.

The northern sections of the SSSI also contain several damp hollows and seasonally flooded dune slacks. These habitats support specialised vegetation communities associated with wetter conditions, including patches of creeping willow (*Salix repens*), and provide habitat for several notable plant species identified by NatureScot.

For the purposes of this Environmental Assessment, the fixed dune grasslands and dune slack habitats are considered the principal flora receptors due to their botanical importance and their association with the notable plant species for which the site is recognised.

3.2.2. Notable Plant Species

NatureScot identifies several notable plant species within Machrihanish Dunes SSSI, principally associated with the fixed dune grassland and dune slack habitats. The species identified as being of relevance to this assessment are summarised in the table below.

Species	Principal Habitat	Significance	Typical Flowering Period*	Distribution within SSSI	Growth Form / Recovery Characteristics
Pyramidal Orchid (<i>Anacamptis pyramidalis</i>)	Fixed dune grassland	Only known location in Kintyre	June-August	NatureScot identifies abundant populations within fixed dunes	Herbaceous perennial orchid arising from an underground tuber. Individual flowering stems may be vulnerable to physical damage, however the plant persists below ground outside the flowering season.
Field Gentian (<i>Gentianella campestris</i>)	Fixed dune grassland	Notable dune grassland species	July-September	NatureScot identifies abundant populations within fixed dunes	Small annual herbaceous flowering plant occurring throughout fixed dune grassland communities.



Early Marsh Orchid (<i>Dactylorhiza incarnata</i>)	Dune slacks	Notable dune slack species	May-July	Localised within dune slack habitats	Herbaceous orchid associated with seasonally wet dune habitats.
Small-fruited Yellow Sedge (<i>Carex viridula</i> subsp. <i>Viridula</i>)	Dune slacks	Notable dune slack species	Summer	Localised within dune slack habitats	Perennial sedge associated with damp hollows and seasonally flooded dune slacks.
Creeping Willow (<i>Salix repens</i>)	Dune slacks	Characteristic dune slack vegetation	April-May	Localised patches within dune slacks	Low-growing perennial woody shrub capable of vegetative regeneration.

* Typical flowering periods are provided as an ecological indicator of seasonal activity and visibility and do not represent periods of plant presence. Species may remain present outside these periods as dormant, vegetative or non-flowering forms.

NatureScot additionally identifies strandline and foredune vegetation communities containing sea rocket (*Cakile maritima*), frosted orache (*Atriplex laciniata*), sand couch (*Elymus junceus*) and marram grass (*Ammophila arenaria*). These species are characteristic of dynamic coastal dune systems and contribute to dune formation and stabilisation processes.

3.2.3. Pyramidal Orchid (*Anacamptis pyramidalis*)

Pyramidal orchid (*Anacamptis pyramidalis*) is the most notable botanical species identified within Machrihanish Dunes SSSI and is specifically highlighted by NatureScot as occurring nowhere else within Kintyre. The species is associated with the fixed dune grassland habitats present throughout the dune system, where NatureScot identifies abundant populations occurring alongside field gentian.

Pyramidal orchid is a perennial species that develops from an underground tuber and typically flowers during the summer months. Although the flowering spikes are the most visible component of the plant, the species remains present outside the flowering period in a non-flowering state. The current launch window of October-November therefore falls outside the principal flowering season of the species.

Given that Machrihanish Dunes SSSI represents the only known location for pyramidal orchid in Kintyre, the species has been identified as a key flora receptor within this assessment. The potential effects of launch activities, vehicle touchdown and recovery operations on pyramidal orchid and associated dune grassland habitats are assessed in Section 3.2.4.



3.2.4. Assessment of Potential Effects on Flora

The flora present within Machrihanish Dunes SSSI may be exposed to the proposed activity through three principal impact pathways:

1. vehicle overflight of the dune system during ascent;
2. vehicle touchdown within the SSSI under nominal or off-nominal recovery scenarios;
3. recovery personnel accessing landed hardware within the dune system.

The launch will comprise a single, short-duration event from Machrihanish Airbase, with the vehicle following a westward trajectory over Machrihanish Bay before descending under the recovery scenarios described within EXO_SSL_NRA. Monte Carlo trajectory modelling indicates that touchdown within the SSSI is possible under certain recovery scenarios, although the likelihood varies significantly between scenarios. No touchdowns within the SSSI were predicted under the ballistic case.

3.2.4.1. Launch Overflight

Potential effects arising from vehicle overflight are limited to temporary noise and visual disturbance. As flora does not respond to short-duration visual disturbance and no direct physical interaction occurs during overflight, adverse effects on dune vegetation communities are not anticipated through this pathway. The overflight duration is brief and does not involve any direct removal, modification or fragmentation of dune habitats.

3.2.4.2. Vehicle Touchdown

The probability of vehicle touchdown within Machrihanish Dunes SSSI is summarised in Section 3.1. The highest likelihood occurs under the main-at-apogee recovery scenario, where 59.1% of simulated landing locations fall within the SSSI boundary. This therefore represents the most conservative scenario for assessment of potential effects on flora.

The principal effect of a touchdown within the SSSI would be highly localised physical disturbance to vegetation at the landing location. Any disturbance would be restricted to the footprint of the vehicle and recovery system and would not result in habitat loss, habitat fragmentation, alteration of dune processes or changes to the hydrological conditions that support dune slack habitats. The affected area would represent a negligible proportion of the approximately 293 ha SSSI.

As described in Section 3.2.3, pyramidal orchid (*Anacamptis pyramidalis*) has been identified as the principal botanical receptor within the SSSI. Although touchdown within the SSSI is possible under certain recovery scenarios, any disturbance would be confined to a very small area relative to the extent of suitable habitat available across the dune system. Consequently, the likelihood of direct interaction with an individual plant is lower than the overall probability of touchdown within the designated boundary itself.

Furthermore, direct interaction with an individual plant would not necessarily result in damage. Even if one or more individual specimens were damaged, the effect would be confined to a very small number of plants and would not affect the viability of the wider population or the integrity of the SSSI. The proposed launch window of October-November also falls outside the principal flowering period of pyramidal orchid.

A similar conclusion applies to the other notable flora identified within the SSSI. A single touchdown event would not alter the habitat conditions that support the fixed dune grassland and dune slack communities and therefore would not result in lasting effects on the wider flora assemblage. The flora present within Machrihanish Dunes SSSI is characteristic of an exposed Atlantic coastal environment. Historical meteorological records for the Machrihanish



area indicate that wind speeds exceeding 40 mph are not uncommon during autumn and winter storm events. The dune vegetation communities present within the SSSI are therefore adapted to regular exposure to strong winds, salt spray, sand movement and other forms of natural physical disturbance. Whilst vehicle touchdown has the potential to cause localised effects at the point of landing, the scale and duration of disturbance associated with a single launch event is minor when compared with the natural environmental conditions routinely experienced across the dune system. This suggests a high capacity for recovery from any localised disturbance that may occur.

Considering the limited physical footprint of a touchdown, the distribution of notable flora across the dune system and the single-event nature of the proposed activity, the impact of vehicle touchdown on flora is considered **negligible**. Any effects would be localised, temporary and reversible.

3.2.4.3. Recovery

In the unlikely event that recovery is required from within Machrihanish Dunes SSSI, recovery activities will be undertaken so far as reasonably practicable to minimise disturbance to dune habitats and associated flora. Recovery personnel will utilise existing access routes where available and avoid unnecessary trampling of vegetated areas during access to the vehicle. Where practicable, the vehicle will be lifted and carried from the touchdown location rather than dragged across dune vegetation. Recovery activities would be short in duration, localised in extent, and involve a limited number of personnel. As such, any effects associated with recovery operations are expected to be temporary, localised and reversible. Significant adverse effects on the botanical interest of Machrihanish Dunes SSSI are not anticipated.

3.3. Avifauna

3.3.1. Baseline Avifauna

Information on avifauna within the wider Machrihanish area has been obtained from publicly available bird recording datasets and local birdwatching records. As these records relate to the wider Machrihanish locality rather than specifically to Machrihanish Dunes SSSI, the data has been used to identify the types of bird species that may utilise the beach, dune and nearshore habitats surrounding the proposed launch site, rather than to establish a definitive site-specific species inventory. For the purposes of this assessment, species have been grouped into broad receptor categories including waders, gulls, waterfowl, seabirds and raptors, as species within these groups generally exhibit similar habitat use and behavioural responses to short-duration disturbance events.

Records from the wider Machrihanish area indicate the presence of species groups including waders, gulls, waterfowl, seabirds and occasional raptors. Representative species recorded within the locality include oystercatcher, redshank, turnstone, purple sandpiper, common gull, herring gull, great black-backed gull, eider, red-breasted merganser, shag, cormorant and peregrine falcon.

3.3.2. Notable Bird Species

For the purposes of this assessment, species have been grouped according to their habitat use and likely behavioural response to temporary disturbance. The principal avian receptors identified within the wider Machrihanish area are summarised in the table below.



Bird Group	Representative Species Recorded Locally	Principal Habitat
Waders	Oystercatcher, Redshank, Turnstone, Purple Sandpiper	Beach and intertidal areas
Gulls	Common Gull, Herring Gull, Great Black-backed Gull	Beach, dunes and nearshore waters
Waterfowl	Eider, Red-breasted Merganser, Goldeneye, Long-tailed Duck	Nearshore waters
Seabirds	Shag, Cormorant, Black Guillemot	Coastal and marine waters
Raptors	Peregrine Falcon	Occasional coastal foraging and transit

Given the coastal nature of the site and the proposed launch trajectory over the beach and adjacent nearshore waters, waders, gulls, waterfowl and seabirds are considered the primary avian receptors for the purposes of this assessment. These groups are likely to exhibit similar behavioural responses to short-duration disturbance events such as launch noise, vehicle overflight and recovery activities.

3.3.3. Seasonal Considerations

The proposed launch is currently scheduled for October-November, outside the principal breeding season for most coastal and marine bird species that may utilise the Machrihanish area. As a result, the potential for effects on nesting birds, eggs and dependent young is substantially reduced compared with activities undertaken during the spring and summer months.

During the proposed launch period, avian receptors are expected to comprise primarily foraging, roosting, overwintering and passage birds utilising the beach, dune and nearshore habitats surrounding the launch site. Consequently, the principal impact pathway considered within this assessment is temporary behavioural disturbance arising from launch activities, rather than impacts to breeding success or nesting habitat.

3.3.4. Assessment of Potential Effects on Avifauna

The assessment considers launch noise, overflight, touchdown and recovery, with reference to the seasonal context described in Section 3.3.3.



3.3.4.1. Launch

The launch event represents the primary pathway for avian disturbance due to the short-duration noise generated during motor ignition and powered ascent. The proposed Lowlander launch will utilise a CTI M1450-CL solid rocket motor, which produces a peak thrust of approximately 2,416 N and has a burn duration of approximately 6.9 seconds. The M1450-CL represents the longest burn duration of the candidate commercial off-the-shelf motors assessed for the Lowlander programme and has therefore been considered a conservative case for assessment of launch-related disturbance.

Birds present within the beach, dune and nearshore habitats may exhibit a temporary behavioural response to launch noise, including alerting behaviour, short-term flushing and localised displacement from the immediate area. Similar responses are commonly observed in birds exposed to sudden and intermittent disturbance events and would be expected to cease once the launch has concluded.

The proposed launch is scheduled for October-November, outside the principal breeding season for the majority of coastal and marine bird species that may utilise the Machrihanish area. Consequently, whilst individual birds may temporarily relocate from the immediate launch area, no effects on nests, eggs or dependent young are anticipated. The assessment therefore focuses on short-term behavioural disturbance to foraging, roosting and overwintering birds only.

The wider Machrihanish area is already subject to routine aircraft activity associated with scheduled Campbeltown Airport services. Aircraft operating on routes west of Machrihanish regularly pass through the wider coastal environment used by local bird populations. Whilst aircraft operations are not directly comparable to a rocket launch, this indicates that local avifauna are not isolated from intermittent disturbance from flights.

In addition, rocket motor testing and aerospace activities are already undertaken within the wider Machrihanish Airbase environment. Whilst these activities are not directly comparable to the acoustic characteristics of a launch event, they indicate that the local area is not entirely free from occasional high-intensity operational noise sources. Taking into account the single-event nature of the launch, the short duration of powered flight, and the absence of a breeding bird pathway, any launch-related disturbance is expected to be temporary and reversible. Significant adverse effects on local avifauna are not anticipated.

3.3.4.2. Launch Overflight

Following launch, the vehicle will pass over the beach, dune system and adjacent nearshore waters before continuing offshore. Aside from the launch noise already assessed in Section 3.3.4.1, the overflight itself is not anticipated to result in significant disturbance. Birds may exhibit temporary alerting behaviour or short-distance displacement; however, the likelihood of direct interaction between the vehicle and an individual bird is considered extremely low. Launch operations will remain subject to visual monitoring and may be delayed should unusual concentrations of birds be observed within the immediate launch area. Significant adverse effects arising from vehicle overflight are not anticipated.

3.3.4.3. Vehicle Touchdown

As discussed in Section 3.1, vehicle touchdown within Machrihanish Dunes SSSI is only predicted under certain recovery scenarios. In the unlikely event that a touchdown occurs in an area occupied by birds, individuals may exhibit short-term avoidance behaviour prior to landing. Given the relatively low descent rates associated with the recovery system, the ability of birds to move away from approaching objects, and the small footprint of the vehicle, the



likelihood of direct interaction with avifauna is considered negligible. Significant adverse effects on avifauna arising from vehicle touchdown are not anticipated.

3.3.4.4. Recovery

In the unlikely event that recovery is required from within Machrihanish Dunes SSSI, recovery activities may result in temporary localised disturbance to any birds present in the immediate vicinity of the touchdown location. Recovery operations would be short in duration, involve a limited number of personnel, and be restricted to a small area. Any affected birds would be expected to relocate temporarily and return once recovery activities have ceased. Significant adverse effects on avifauna are not anticipated.

4. Sound of Gigha SPA

4.1. Site Description and Features

The Sound of Gigha Special Protection Area (SPA) is a marine European designated site located off the west coast of the Kintyre Peninsula and centred around the island of Gigha. The SPA extends from Machrihanish Bay in the south to the entrance of Loch Caolisport in the north and includes the Sound of Gigha and West Loch Tarbert. The site covers approximately 363 km² of marine waters and forms part of Scotland's wider network of protected marine sites.

The SPA has been designated to protect internationally important populations of wintering waterfowl and their supporting marine habitats. The qualifying features comprise great northern diver (*Gavia immer*), Slavonian grebe (*Podiceps auritus*), common eider (*Somateria mollissima*) and red-breasted merganser (*Mergus serrator*). The site supports nationally and internationally important proportions of the Great Britain populations of these species and provides important habitat for foraging, roosting, moulting and overwintering activities.

The SPA encompasses a variety of coastal and marine habitats including shallow coastal waters, sheltered bays, channels and offshore waters. The complex bathymetry and diversity of marine habitats support a range of fish, crustaceans and molluscs which provide important prey resources for the qualifying bird species.



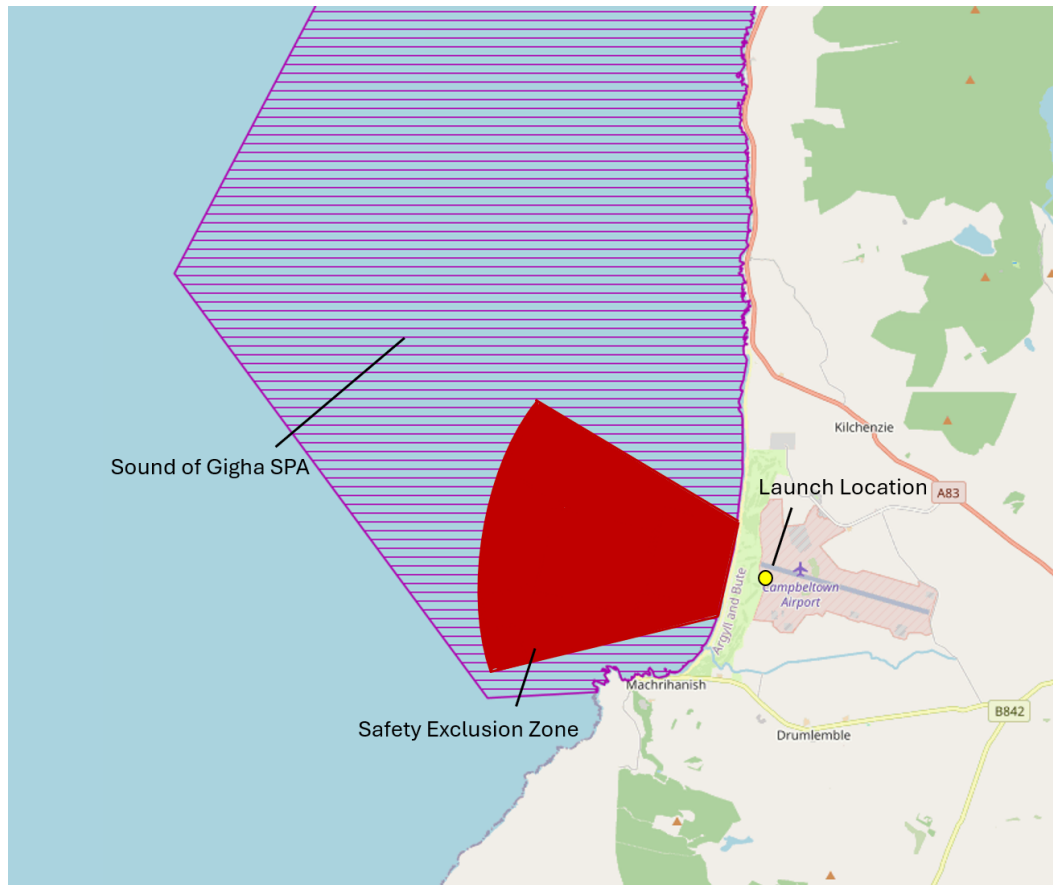


Figure 2 - Sound of Gigha SPA

As shown in Figure 2, the proposed launch trajectory, Safety Exclusion Zone (SEZ) and splashdown area are located within the southern extent of the SPA. The launch vehicle will travel westwards from Machrihanish Airbase through the SPA before descending under parachute and splashing down within coastal waters west of Machrihanish.

NatureScot's Conservation Objectives for the SPA seek to maintain the qualifying species as viable components of the site, maintain their distribution throughout the SPA by avoiding significant disturbance, and maintain the supporting habitats, ecological processes and prey resources upon which the qualifying species depend. Consequently, this assessment considers the potential for temporary behavioural disturbance to qualifying bird species, together with any potential effects on supporting habitats and prey resources arising from launch, overflight, splashdown and recovery activities.

4.2. Qualifying Species of the Sound of Gigha SPA

The Sound of Gigha SPA is designated for four species of non-breeding waterfowl and their supporting marine habitats. The site qualifies under Article 4.1 of the Birds Directive for regularly supporting wintering populations of European importance of great northern diver (*Gavia immer*) and Slavonian grebe (*Podiceps auritus*), both Annex I species. The site also qualifies under Article 4.2 for regularly supporting migratory populations of European importance of common eider (*Somateria mollissima*) and red-breasted merganser (*Mergus serrator*).



Qualifying Species	Designation Basis	Citation Population	Principal Habitat Use
Great Northern Diver (<i>Gavia immer</i>)	Article 4.1 Annex I species	505 individuals (20.2% of GB population)	Open coastal waters, sheltered bays and channels used for foraging, roosting and overwintering
Slavonian Grebe (<i>Podiceps auritus</i>)	Article 4.1 Annex I species	37 individuals (3.4% of GB population)	Sheltered coastal and inshore waters used for foraging, roosting and overwintering
Common Eider (<i>Somateria mollissima</i>)	Article 4.2 migratory species	1,295 individuals (2.2% of GB population)	Coastal waters, shallow bays and sheltered marine habitats
Red-breasted Merganser (<i>Mergus serrator</i>)	Article 4.2 migratory species	117 individuals (1.4% of GB population)	Coastal and nearshore waters, typically close to shore

The qualifying species utilise the SPA for a range of activities including foraging, roosting, moulting and overwintering. Great northern divers and Slavonian grebes are afforded particular conservation importance within the SPA as Annex I species and NatureScot identifies these species as the primary conservation priorities where management decisions are required.

NatureScot's Conservation Objectives require the populations of the qualifying species to remain viable components of the site, their distribution throughout the SPA to be maintained through the avoidance of significant disturbance, and their supporting habitats and prey resources to remain available. Consequently, the principal impact pathway considered in this assessment is temporary behavioural disturbance or displacement resulting from launch activities.

4.3. Seasonal Considerations

The proposed launch is scheduled for October-November, which coincides with the non-breeding season of the qualifying bird species for which the Sound of Gigha SPA has been designated. During this period, the SPA supports wintering populations of great northern diver and Slavonian grebe, together with non-breeding and overwintering populations of common eider and red-breasted merganser.



Unlike the avifauna associated with Machrihanish Dunes SSSI, the qualifying features of the SPA are specifically designated for their use of the marine environment during the non-breeding season. Consequently, the assessment focuses on the potential for temporary disturbance to foraging, roosting and overwintering birds rather than effects on breeding activity, nests or dependent young.

NatureScot advises that temporary short-term disturbance does not necessarily compromise the Conservation Objectives of the SPA, provided affected birds are able to recover and continue to utilise the site for essential behaviours such as feeding, roosting and movement between habitats. The significance of any disturbance therefore depends on its duration, frequency, spatial extent and the ability of birds to resume normal use of the SPA following the activity.

4.4. Assessment of Potential Effects to the Sound of Gigha SPA

4.4.1. Launch Noise

The launch event represents the primary noise-related disturbance pathway for qualifying bird species within the Sound of Gigha SPA. Noise generation is limited to the powered ascent phase of flight, which is expected to last approximately 7 seconds. Commercial air services operating between Campbeltown and Glasgow currently undertake two inbound and two outbound flights each weekday. The associated flight paths pass west of Machrihanish and over parts of the Sound of Gigha SPA, including the proposed splashdown area. At the western extent of the turning manoeuvre, aircraft typically operate at an altitude of approximately 2,500 ft (WGS84). The qualifying species and supporting habitats within the SPA are therefore already subject to routine aircraft activity throughout the year. In contrast, the proposed Lowlander launch comprises a single, short-duration event. Figure 3 below shows the routine Campbeltown Airport flight path to Glasgow Airport.



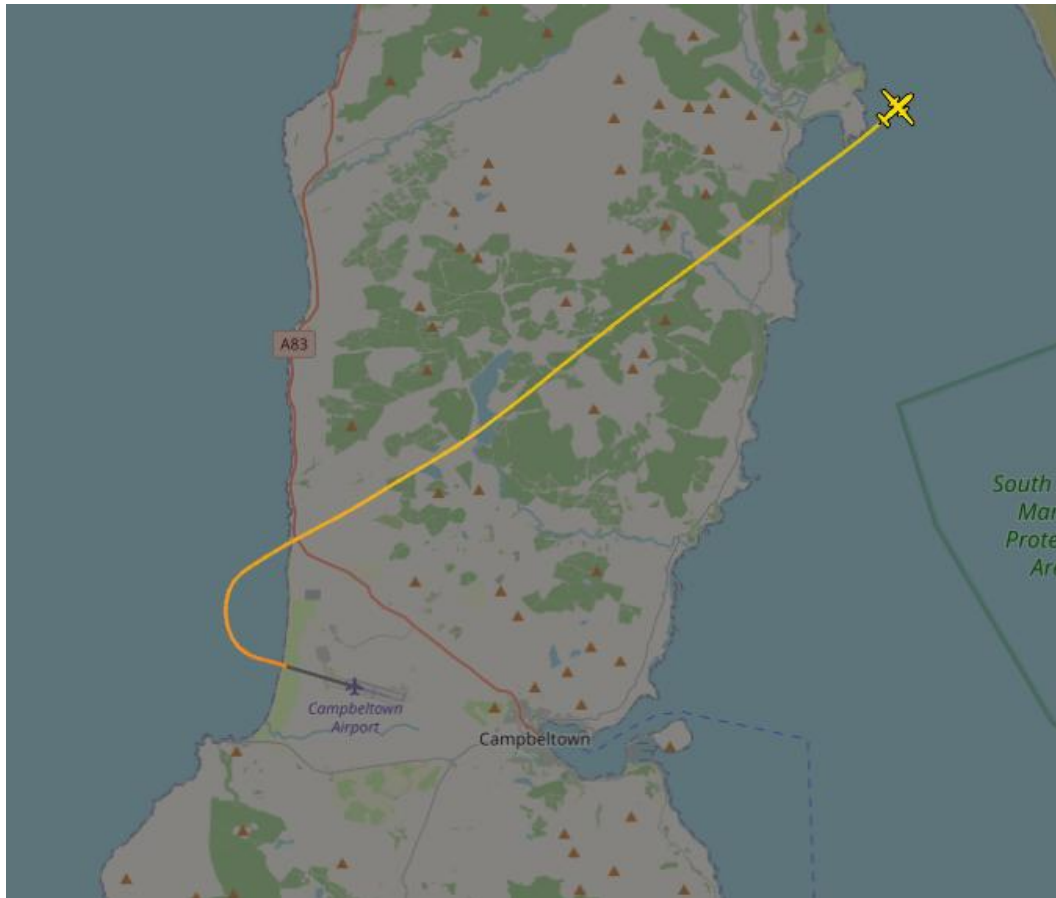


Figure 3 - Campbeltown Flight Path

The majority of this phase occurs immediately following launch over land, including Machrihanish Dunes SSSI. By the time the launch vehicle enters the SPA, it is expected to have reached an altitude of approximately 2 km and will continue climbing towards an apogee of approximately 3-4 km before motor burnout. Following burnout, no further significant propulsion-related noise will be generated.

Qualifying species within the SPA may exhibit temporary behavioural responses such as alerting behaviour, flushing or short-distance displacement. However, given the short duration of the powered flight and the limited period during which launch noise will be experienced within the SPA, any disturbance is expected to be temporary and localised. Significant adverse effects on the integrity of the Sound of Gigha SPA are not anticipated.

4.4.2. Vehicle Overflight and Splashdown

Following motor burnout, the vehicle will continue through the Sound of Gigha SPA before descending under parachute and splashing down offshore. The likelihood of direct interaction between the vehicle and qualifying bird species is considered negligible due to the small dimensions of the vehicle, the large volume of airspace and marine habitat available, and the ability of birds to avoid approaching objects. Significant adverse effects on the qualifying features of the Sound of Gigha SPA arising from vehicle overflight or splashdown are therefore not anticipated.



4.4.3. Nominal Recovery Activities

Recovery activities have the greatest potential to disturb qualifying species due to the temporary presence of recovery vessels within the SPA. As described in EXO_SSL_NRA, recovery will be undertaken using a limited number of small vessels operating for a short duration following splashdown. AIS data presented in EXO_SSL_NRA demonstrates that recreational and pleasure craft already routinely utilise the wider area. Consequently, the temporary presence of one or more recovery vessels is not expected to result in a material increase in vessel activity within the SPA. Any disturbance is expected to be temporary and localised and significant adverse effects on the integrity of the SPA are not anticipated.

5. Atmospheric Impact

The proposed activity comprises a single launch event with propulsion lasting approximately 6.9 seconds and involving the combustion of approximately 4.83 kg of APCP propellant. Following motor burnout no further propulsion-related emissions are produced. Given the limited quantity of propellant consumed, the short duration of the event and the rapid dispersion of combustion products in the atmosphere, no measurable deterioration in local or regional air quality is anticipated. Significant adverse effects on atmospheric conditions are therefore not anticipated. Atmospheric impacts associated with the proposed launch are considered negligible due to the short duration of powered flight, limited propellant consumption and absence of any ongoing emission source.

6. Unrecovered Debris Scenario

The material composition, recovery configuration and environmental fate of Lowlander vehicle components have been assessed within EXO_SSL_BPEO. Under nominal conditions, all major components remain tethered, are supported by flotation systems and are actively recovered following splashdown. In the event that recovery is unsuccessful, the principal residual environmental pathways relate to localised seabed presence, marine litter associated with flexible materials, and potential contamination from electronic components following prolonged immersion. EXO_SSL_BPEO concludes that these risks remain limited in scale and extent, and no significant adverse effects on protected sites or the wider marine environment are anticipated.

7. Summary of Environmental Effects

This section provides a summary of the environmental effects identified during the assessment and the residual effects anticipated following implementation of the embedded mitigation and operational controls described throughout this Environmental Assessment. The assessment has considered the potential effects of the proposed launch, splashdown, recovery activities and the unlikely scenario of unrecovered debris. Detailed assessment findings are presented in Sections 3 to 6.



Receptor	Principal Impact Pathway	Embedded Mitigation / Controls	Residual Effect
Machrihanish Dunes SSSI Flora	Vehicle touchdown and recovery activities within the SSSI	Recovery undertaken so far as reasonably practicable to minimise disturbance, use of existing access routes where available, recovery activities limited in duration and extent	Negligible. Any effects would be localised, temporary and reversible. No significant adverse effects anticipated.
Avifauna	Launch noise, overflight, touchdown and recovery activities	Single launch event, short duration, launch planned outside principal breeding season, recovery activities limited in duration and extent	Temporary behavioural disturbance only. No significant adverse effects anticipated.
Sound of Gigha SPA	Temporary disturbance of qualifying bird species from launch and recovery activities	Single launch event, short duration, no permanent infrastructure, no habitat loss or seabed disturbance	Temporary and localised disturbance only. No adverse effects on the integrity of the SPA anticipated.
Atmospheric Environment	Emissions from rocket motor combustion during ascent	Limited propellant mass and short motor burn duration	Negligible. No measurable deterioration in air quality anticipated.
Marine Environment (Unrecovered Debris Scenario)	Presence of unrecovered vehicle components and associated marine litter pathways	Vehicle designed for recovery using tethered assemblies, flotation devices and active recovery procedures	Residual risks are limited in scale and extent. No significant adverse effects on the marine environment anticipated. Refer to EXO_SSL_BPEO for further details.



8. Conclusion

This Environmental Assessment has considered the potential environmental effects associated with the proposed Lowlander Pathfinder launch and associated recovery activities at Machrihanish. The assessment has examined potential effects on the botanical interest of Machrihanish Dunes SSSI, local avifauna, the qualifying species of the Sound of Gigha SPA, atmospheric conditions, and the marine environment.

The proposed activity comprises a single launch event of short duration, involving a westward launch trajectory from Machrihanish Airbase, a controlled descent under parachute recovery systems, and recovery of the vehicle following splashdown. The assessment has considered both nominal operations and reasonably foreseeable off-nominal scenarios, including the potential for vehicle touchdown within the Machrihanish Dunes SSSI and the unlikely scenario of unrecovered debris within the marine environment.

The assessment concludes that potential effects on the flora of Machrihanish Dunes SSSI would be localised, temporary and reversible, and significant adverse effects are not anticipated. Potential effects on avifauna are limited to temporary behavioural disturbance associated with launch and recovery activities, with no significant adverse effects anticipated. Similarly, temporary and localised disturbance to qualifying species of the Sound of Gigha SPA may occur during launch operations; however, significant adverse effects on the integrity of the SPA are not anticipated.

Atmospheric impacts are expected to be negligible due to the limited quantity of propellant utilised, the short duration of the powered flight, and the rapid dispersion of combustion products following launch. No measurable deterioration in local or regional air quality is anticipated.

The potential environmental implications of unrecovered debris have also been considered. The assessment concludes that any residual risks associated with unrecovered components would be limited in scale and extent and are not anticipated to result in significant adverse effects on protected sites or the wider marine environment.

Taking account of the nature, scale and duration of the proposed activity, the assessment concludes that significant adverse environmental effects are not anticipated. Any effects identified are expected to be temporary, localised and reversible in nature.

