BORD NA MÓNA – BALLYCON BOG

Drainage Management Plan

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EXECUTIVE SUMMARY

Ballycon Bog is located in Co. Offaly, approximately 10km southwest of Edenderry. Ballycon Bog discharges directly to the Philipstown River to the north where it meets the Daingean river north east of the bog. The bog also discharges via adjacent land drains to the south to the Daingean River a Tributary of the Figile River.

The rehabilitation measures will generally result in reduced runoff and drainage from the existing peat fields through a mixture of techniques including wetland creation, drain blocking, cell bunding and re-profiling. It is assumed that these measures will not significantly alter the existing topographical catchments, water table rise, increased runoff from the bog and low flow risk.

Potential impacts were considered: the potential for changes in flows downstream and the potential for increased water table levels impacting adjacent lands. Observations from previous rehabilitation measures, which have returned peatlands to their natural water retention function, has shown a reduction in the downstream run off. Based on this evidence the rehabilitation of Ballycon Bog will result in reduced downstream flows.

The potential for increased water table levels and to a lesser extent marginal alteration of the topographical catchments has been assessed based on a precautionary approach. The rehabilitation measures proposed for Ballycon Bog will result in the alteration of existing wetland areas and it is expected that rehabilitated water levels will be higher than the peat field surface. In this scenario adjacent lands which are at a lower level than these parts of the bog could potentially be impacted. These vulnerable areas have been defined through a zone of influence approach.

Risk of low flow conditions in drains downstream of Ballycon Bog was found to be low in all subcatchments therefore no further assessment was recommended for Ballycon bog.

Each of the land parcels have been assessed based on its vulnerability to increased water table levels within the bog. With a lack of suitable boundary drains in some locations to separate the rehabilitation area and potentially vulnerable lands, constraints to the bog rehabilitation plan were considered.

DMP measures include,

- Retention of boundary drains
- Maintenance of one existing discharge points with silt control
- Implementing silt control measures at one discharge point
- Excluding 2 areas of rehabilitation on the bog to act as a buffer between the bog rehabilitation areas and the adjacent agricultural land
- Retaining 1 drain outside the boundary but within land in the possession of BnM which will act as a hydraulic break where a water sensitive environment exists between the boundary and the drain.

In the event that the monitoring, which will be undertaken by BnM, identifies an adverse water table or drainage impact to adjacent lands in relation to present day conditions accounting for seasonal variability, a suite of measures can be chosen from and will be implemented to establish suitable mitigation. This approach

accounts for unknowns and limitations inherent in this DMP study and provides a precautionary approach to drainage management.

1 INTRODUCTION

Ballycon Bog is located in Co. Offaly, approximately 10km southwest of Edenderry, further site details are described in the Ballycon Bog Site Characterisation Report 2022, thereafter referred to as the Characterisation Report. Ballycon Bog is part of the Allen-Clonsast Bog Group. Bord na Móna operated peat extraction within the Allen-Clonsast Bog Group under IPC Licence (Ref. P0501-01) issued and administered by the EPA. Condition 10.2 of this licence requires the preparation of Ballycon Bog- Cutaway bog decommissioning and rehabilitation plan 2021[1], thereafter referred to as the Rehabilitation Plan, for permanent rehabilitation of the boglands within the licensed area.

It is proposed by Government that Bord na Móna carry out enhanced decommissioning, rehabilitation and restoration under the Peatlands Climate Action Scheme on peatlands previously used for energy production. This proposed Scheme will significantly go beyond what is required to meet rehabilitation and decommissioning obligations under existing EPA IPC licence conditions. Improvements supported by the Scheme will ensure that environmental stabilisation is achieved and significant additional benefits, particularly relating to climate action and other ecosystem services, will also be delivered.

One of the key issues for Bord na Móna is the potential hydrological impact rehabilitation of this bog may have on the bog, surrounding lands and lands downstream which may be hydrologically linked to the bog. Rehabilitation measures generally seek to increase water table levels and surface water retention such that they are closer to the surface to encourage peat formation, the associated ecological benefits and carbon sequestration capacity. While in general terms this will reduce the volume of water released from the bog following a rainfall event, the impact on flood run-off is less predictable. Furthermore the increase in the local water table could result in negative impacts to surrounding lands if mitigation measures are not applied.

This Drainage Management Plan (DMP) for Ballycon Bog seeks to establish the baseline hydrological performance of the bog and the surrounding drainage network. The plan sets out the characterisation of the bog and surrounding lands, the existing performance of the drainage network and the level of flood risk. The plan identifies the potential hydrological zone of influence of the bog and the objectives, risks and opportunities associated with the rehabilitation of the bog. The plan assesses the potential impact of the various rehabilitation measures which are proposed on the local drainage network and flood risk. It sets out, where necessary, mitigation measures required to reduce or avoid impacts. The plan sets out the measures which are required to be delivered in advance or in parallel with the rehabilitation plan as well as the long term operation and retention of the drainage network and associated infrastructure. The plan assesses the level of residual risk, the potential impact due to climate change and the adaptability of measures in response to these climate change impacts.

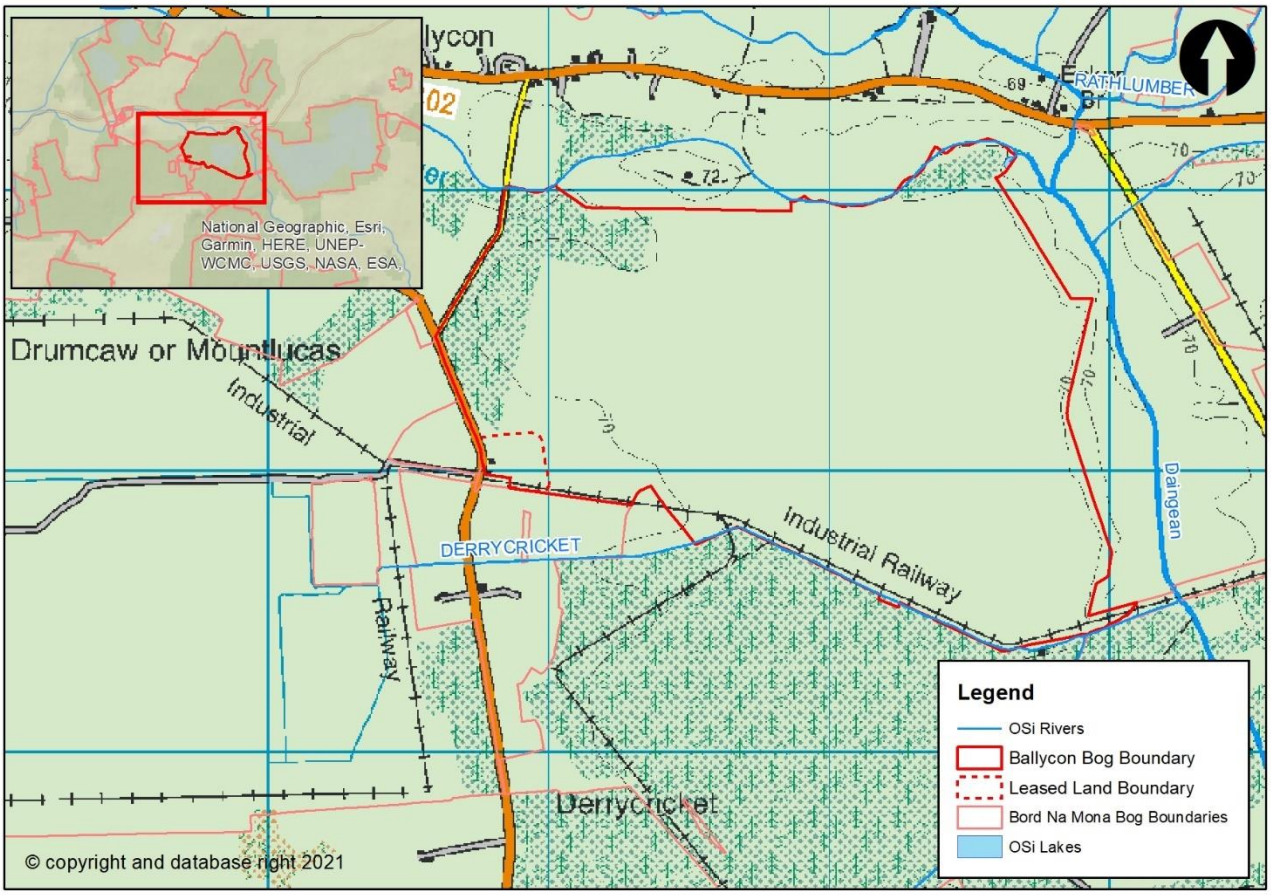

Figure 1-1 Location of Ballycon Bog[1]

[1] Further maps and figures can be found in the Ballycon Bog GIS map book 2022

2 BASELINE ASSESSMENT

Through cessation of peat extraction and implementation of the Rehabilitation Plan there is the potential to hydrologically impact the adjacent land. The extent of the impact will depend on the existing baseline characteristics of the catchments which drain the bog and the adjacent lands.

The purpose of characterising the catchment area is to develop an understanding of how the catchment currently operates and drains. The characterisation also investigates the risks, constraints and opportunities to the operation and drainage.

2.1 Study Area

To characterise the catchments a study area was determined encompassing the total catchment area draining the bog. Ballycon Bog discharges directly to the Philipstown River to the north where it meets the Daingean river north east of the bog. The bog also discharges via adjacent land drains to the south to the Daingean River a Tributary of the Figile River. A review was carried out to delineate the external drains around the bog as presented in Figure 2.1 along with their associated hydrological catchment area.

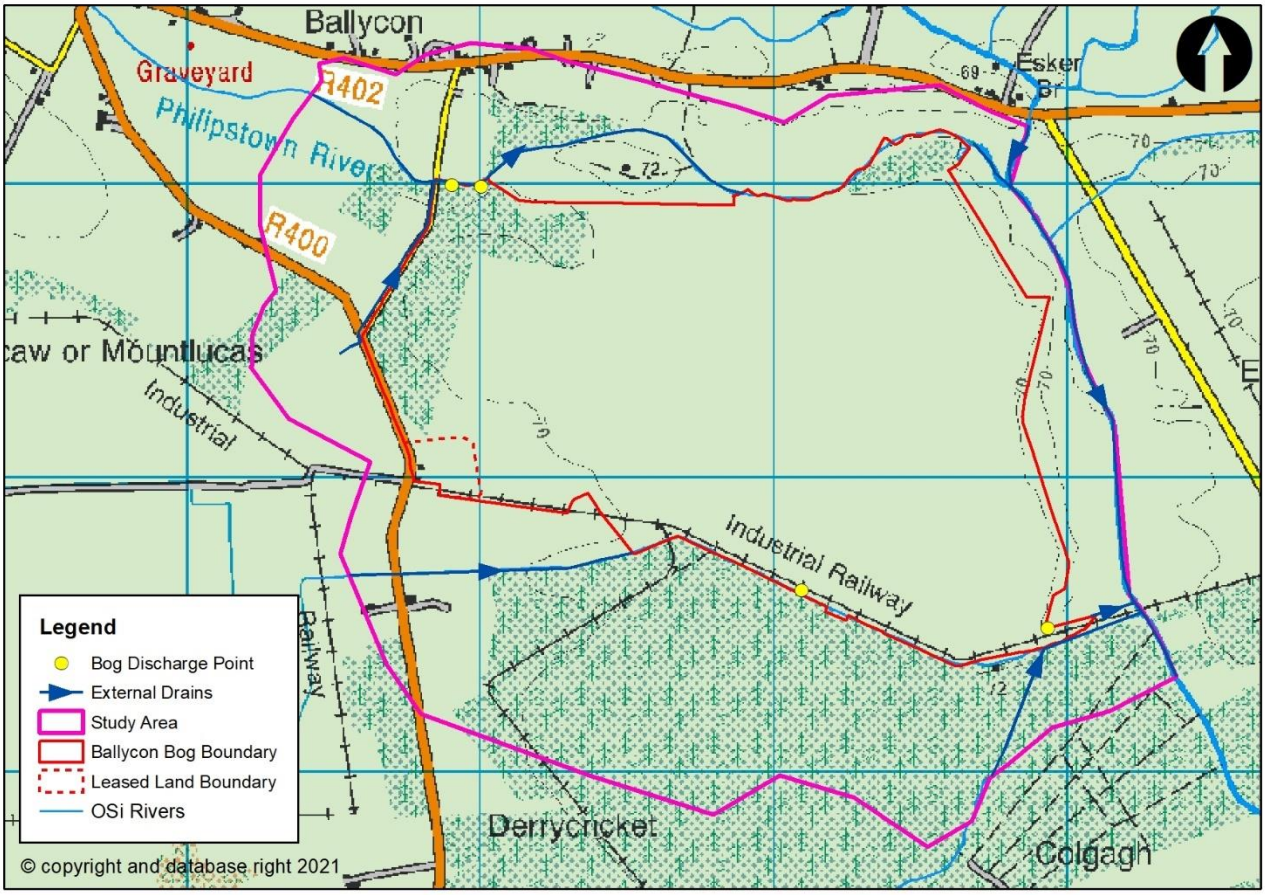

Figure 2-1 Ballycon Bog

2.2 Catchment Runoff Characterisation

A hydrological analysis was carried out within the study area to delineate the sub catchments of the bog drains and the external drains. A recent survey of drainage was carried out by Bord na Móna and this was reviewed, and the bog sub-catchments confirmed. Sub-catchments of the external drains were identified using ARC GIS Hydrology tools. The sub catchments are presented in Figure 2.2.

The Flood Studies Update (FSU) catchment characteristics provide an overview of how much rain a catchment receives, how impermeable the catchment is and how quickly the water will runoff the catchment due to topography and drainage. Table 2.1 summarises the FSU catchment descriptors for the sub-catchments identified in Figure 2-2.

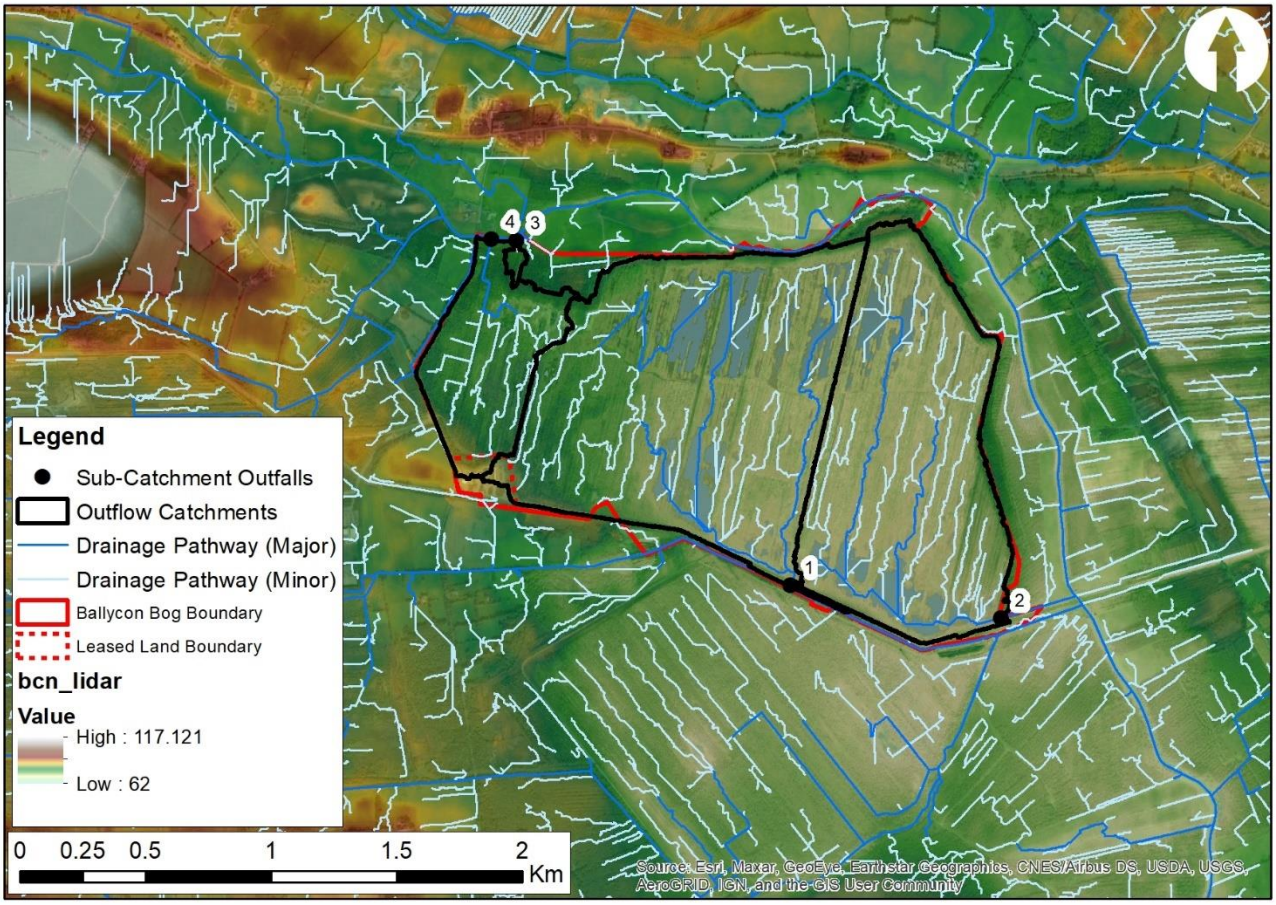

Figure 2-2 Drainage Networks and Sub-Catchments Draining Ballycon Bog

There are four sub-catchments draining Ballycon Bog, catchments area ranging in area from 0.01km^2 to 1.3km^2. The catchments are subject to an average precipitation of 841mm/year. The Baseflow Index for the catchments is between 0.311 and 0.608 representing a low to moderate catchment permeability. The catchments range from moderately flat to steep. This information is based on wider catchment characteristics, and it is acknowledged that these will vary within the bog.

The Index Flood Flow (Q_{med}) values, which represent the typical peak flood flow which might be anticipated (a 50% chance of being exceeded in any given year), for each of the sub-catchments have been calculated. This

is based on two different methods, the Flood Studies Update (FSU) 5 variable equation designed for small and / or urbanised catchments in Ireland, and the RPS derived Peat Q_{med} equation, derived in support of the Drainage Management Plan project for SAC sites on behalf of NPWS. Both methods result in very similar Q_{med} values where the proportion of arterial drainage (ARTDRAIN2) is assumed to match the proportion of the catchment managed by Bord na Móna (i.e.drained).

Table 2-1 Physical Catchment Descriptors of Sub-Catchments Draining the Bog

Sub-Catchment Number	Area (km^2)	SAAR (mm)	BFI	FARL	ARTDRAIN2	PEAT (%)	S1085 (m/km)	FSU5 Q_{MED} (m^3/s)	Peat Q_{MED} (m^3/s)
1	1.30	828	0.311	1	0.000	100.0	0.628	0.345	0.329
2	0.99	825	0.496	1	0.000	80.7	4.514	0.288	0.167
3	0.01	841	0.608	1	0.000	87.1	1.532	0.003	0.003
4	0.32	841	0.608	1	0.000	100.0	6.000	0.093	0.054

2.3 Hydrogeological & Soil Characterisation

Full details of the hydrological and soil characterisation can be found in the Ballycon Bog – site characterisation report 2022.

In summary, Ballycon bog is primarily underlain by the Edenderry Oolite Member and the Waulsortian Limestones. Both units are classified as locally important aquifers as they are moderately productive in local zones only. Additionally, to the east of the bog there is an additional locally important aquifer (karstfied) belonging to the Allenwood Formation. Geological Survey of Ireland (GSI) mapping identifies a single karst feature, a spring, within close proximity to the bog (2-2.5km SW). No data exists concerning depth to bedrock, however, there are areas of bedrock in close proximity to the bog (1.75km NW).

Quaternary Sediment maps show Ballycon underlain by peat, yet surrounded by inorganic deposits, including Limestone till, limestone sands and gravel in addition to basic esker sands and gravel. While Groundwater Vulnerability is typically used to indicate the susceptibility to groundwater pollution, it can provide a useful proxy indication of likely groundwater flow rates in the surrounding area. Groundwater vulnerability for the surrounding areas is generally moderate to high, with some areas of extreme vulnerability identified in the area.

2.4 Morphological and Hydraulic Characterisation

A desk top review was carried out of bog drains and external drains. Morphological and hydraulic features were identified.

The external drains are generally small with gentle bed slopes. Aerial photography shows no signs of erosion or deposition however, given that the drains are considered small with gentle bed slopes there would be a risk of deposition, and therefore reduced land drainage efficiency. Risk of deposition would occur where there is potential for an erosion or debris source from the surrounding land and where there is potential head loss in the channel due to instream features. Figure 2.3 details the reaches of the external drains where there are potential erosion or debris sources and where instream features may facilitate deposition. The figure shows that due to the location of woodlands, commercial forest, and peat in the surrounding lands outside of BnM ownership and control there are existing potential sediment sources that could enter the external drains. Given the presence of culverts, sharp bends, and inflows along the external drains there would be a potential of sediment settling and deposition occurring. The potential for Ballycon bog being a sediment source to the external drains is considered moderate as silt ponds upstream of the discharge points mitigate this potential and where deemed necessary additional silt control measures will be provided

A review of the bog drains was carried out. The Bord na Móna drainage survey details the open drains, settlement silt ponds and discharge points. One of the discharge points from the production fields has a silt pond located upstream. Therefore no measure is in place reducing the amount of peat leaving the bog as water is drained. The drains in the bog have very gentle bed slopes before discharging from the bog. It is anticipated that the bog drainage network would be sensitive to drain and pipe alterations.

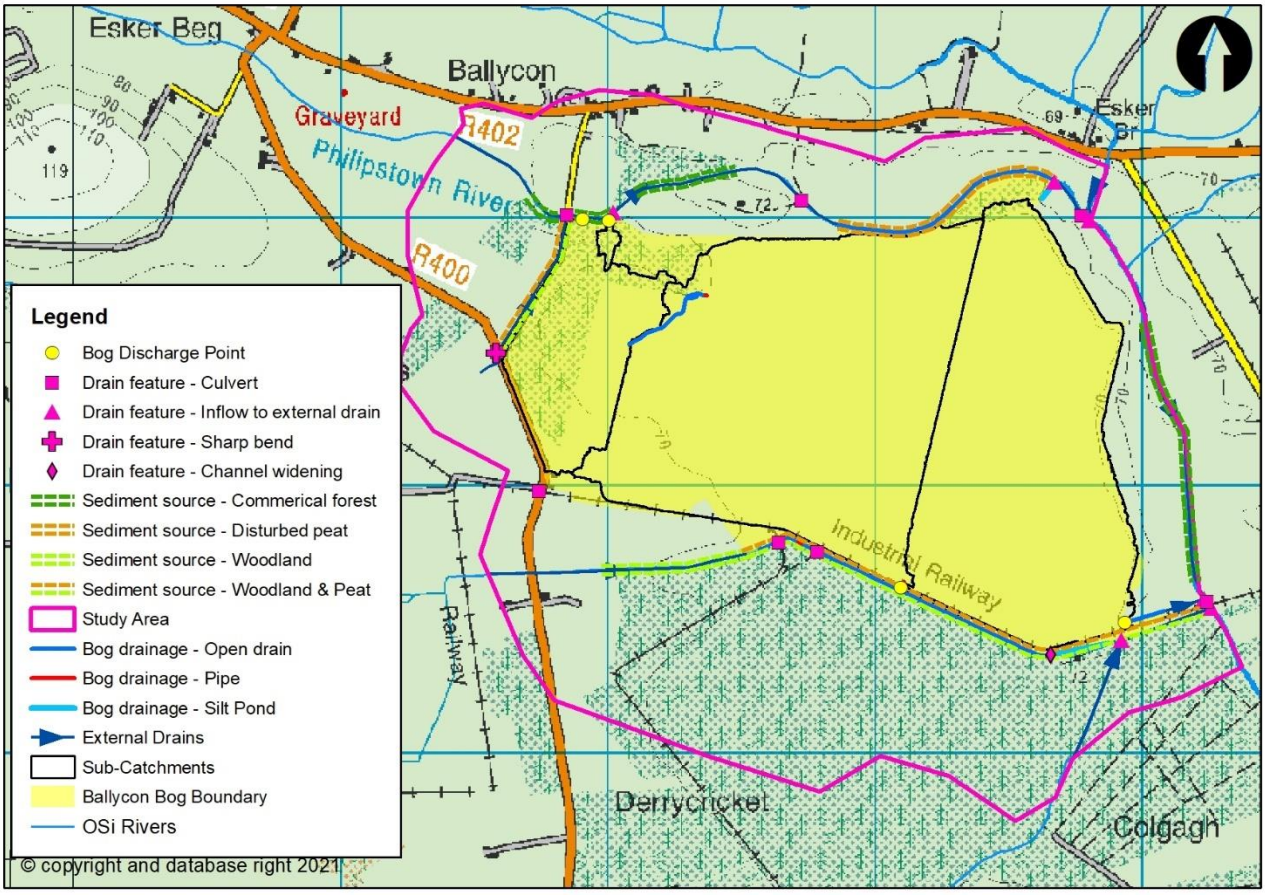

Figure 2-3 Morphological and Hydraulic Characteristics of Ballycon Bog and Environs

2.5 Land Use Character

The majority of the land within the study area is peat bog. The remaining areas of the study area consist of pasture, transitional woodland-shrub and discontinuous urban fabric. The CORINE land use dataset was used to identify landuse types. This dataset was then reviewed using aerial photography to establish land use amendments or land use alterations. The review observed land use changes within the study area with the addition of commercial forestry. Minor roads and properties are located in the study area also.

The pasture land is mainly used for livestock which provides food production. The commercial forests provide for timber production. The peat bogs outside of the Ballycon bog boundary is Mount Lucas Bog to the west and Cloncreen Bog to the east, both are under the possession of Bord na Móna. Other areas of peat bog are undisturbed which contribute to carbon storage and biodiversity. The woodland and shrub areas are likewise providing carbon storage and biodiversity albeit as a different habitat to the peat bogs. The roads within the study areas service properties and provides access to the pastures, forests and peat bogs.

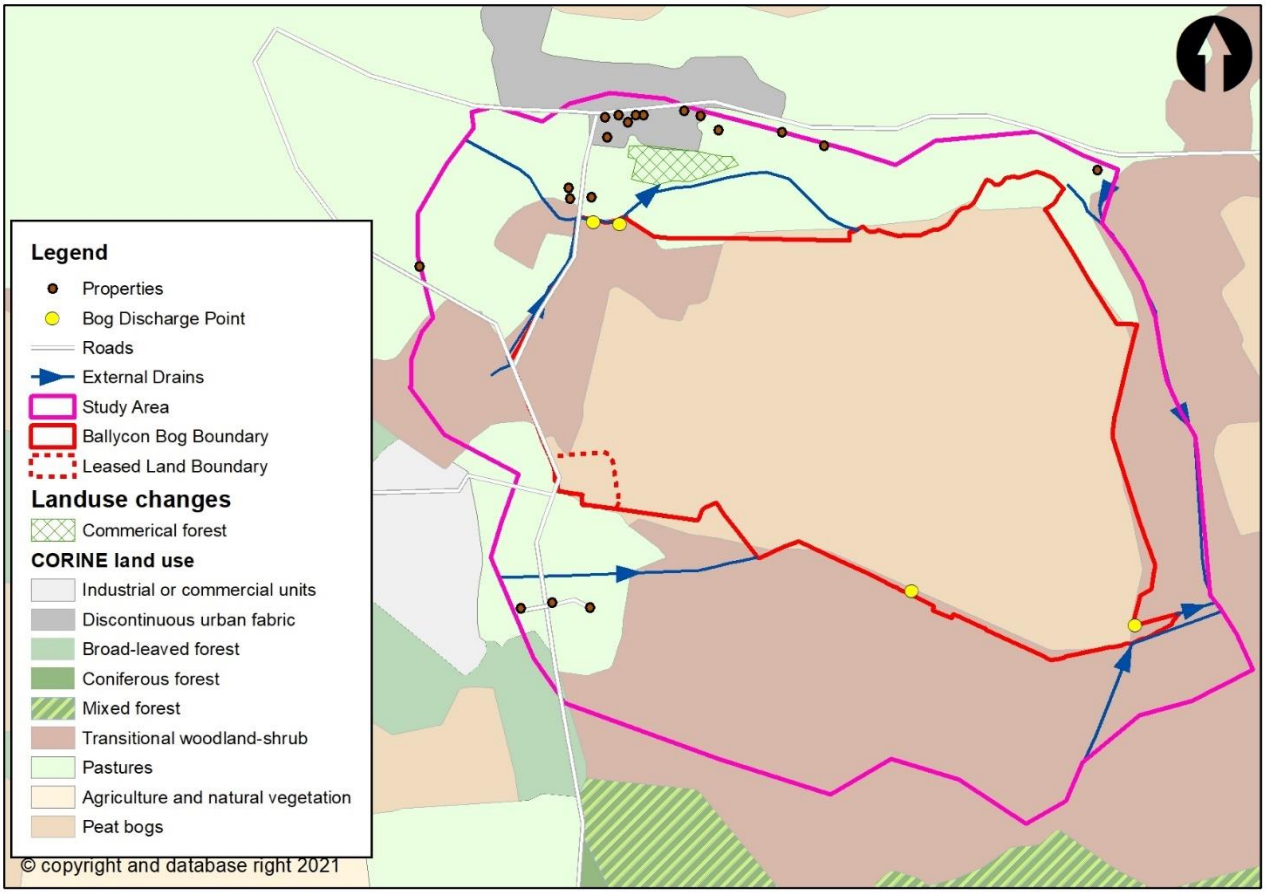

Figure 2-4 Land Use Characteristics of Ballycon Bog and Environs

2.6 Flood Risk

A number of sources of flood risk information are available, both predicted and simulated, in proximity to Ballycon. These include:

- CFRAM Study maps setting out the predicted fluvial 10%, 1% and 0.1% Annual Exceedance Probability (AEP) fluvial flood scenarios
- GSI predicted water table flood maps for high, medium and low probability events
- Mapped fluvial flood extents for the 2009 flood event
- Mapped flood extents for the 2015 flood event (from Sentinel-1 satellite imagery) and a GSI surface water flooding dataset for the same event
- Anecdotal evidence from Bord na Móna

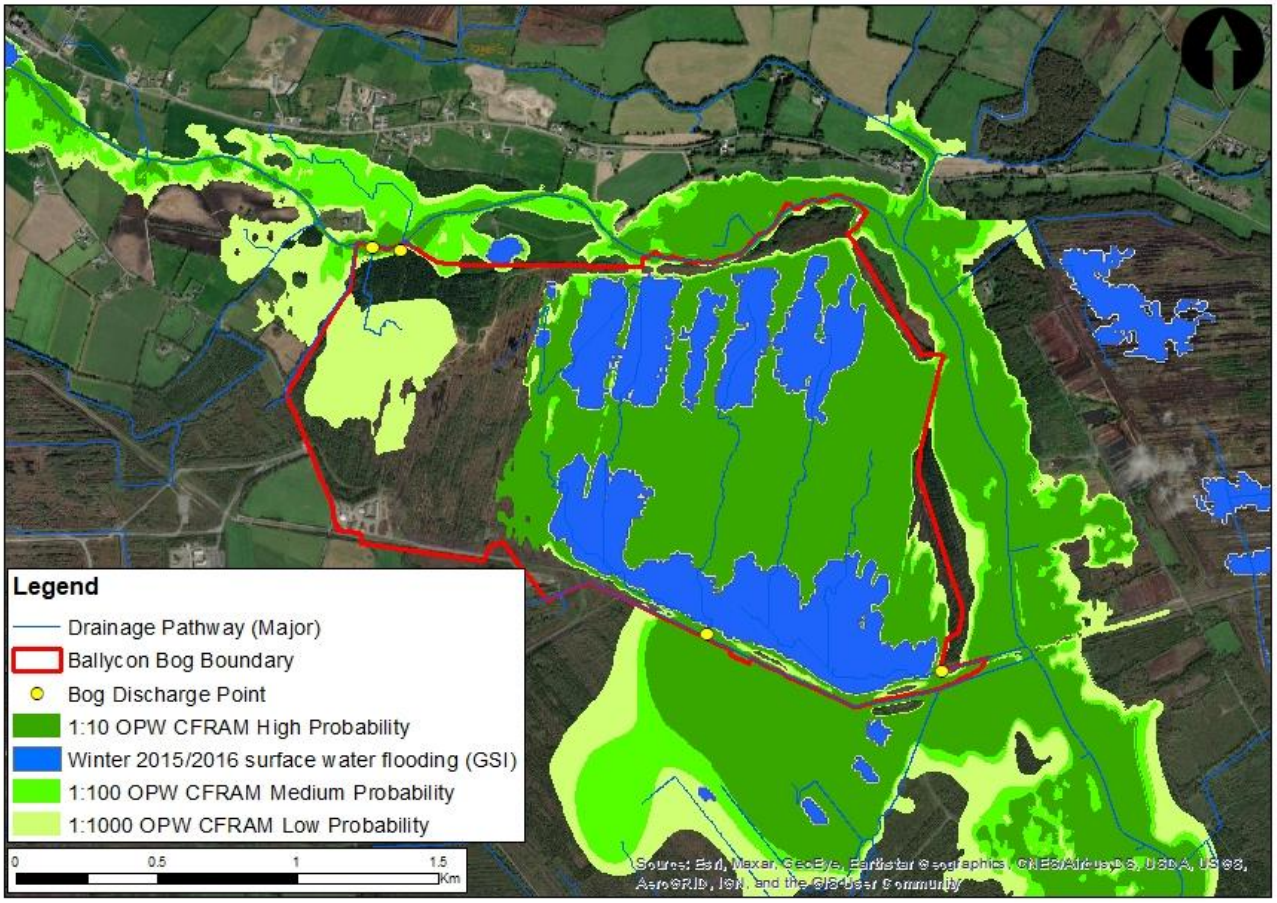

Figure 2-5 Flood Risk and Ballycon Bog

The CFRAM maps show that there is significant risk of Ballycon bog flooding from the Figile River. It should be noted this analysis did not consider the fluvial flood risk from the smaller watercourses which drain the land adjacent to Ballycon bog. The 2015/2016 surface water flooding data supports this indicating flooding has occurred on the bog in the past. This is consistent with the local knowledge from Bord na Móna operatives familiar with Ballycon Bog.

Historical anecdotal evidence was reviewed to ascertain if there are any known flooding or drainage issues from these smaller watercourses to the bog or adjacent land. No drainage issues have been identified along the Ballycon Bog boundary drains.

There is no predicted groundwater flooding to the bog indicated on the GSI datasets.

2.7 Summary

The drainage network sub-catchments within Ballycon Bog and its environs were used to delineate the study area for the Ballycon Drainage Management Plan. The overall catchment area was characterised within the context of hydrology, hydrogeology, morphology, landuse and flood risk.

A detailed drainage network delineation was carried out. Drains within the bog and external drains were identified. The assessment showed that Ballycon Bog discharges directly to the Philipstown River to the north

where it meets the Daingean river north east of the bog. The bog also discharges via adjacent land drains to the south to the Daingean River a Tributary of the Figile River.

The catchment area is considered to be relatively small, flat, high permeability with 841mm annual rainfall. Peak flood flows range from around 0.26-0.29 m^3/s per square kilometre (2.6-2.9 l/s per hectare) for the Q_{med} event to 0.61-0.67 m^3/s per square kilometre (6.1-6.7 l/s per hectare) for the Q_{100} year plus climate change event.

The bedrock within the catchment (Edenderry Oolite Member and the Waulsortian Limestone) may lead to moderate to high rates of groundwater flow. A single spring karst feature was identified in the immediate vicinity of the bog. The subsoil overlying the bedrock is Limestone till, limestone sands and gravel in addition to basic esker sands and gravel which are considered to have a moderate to high permeability.

The morphological and hydraulic characteristics of the external drains were assessed. No signs of erosion of deposition could be observed. Areas of deposition risk were identified along each drain. Culverts, bends, and inflows were identified as potential factors for sediment deposition. Woodlands, commercial forest and peat adjacent to the drains were identified as potential sources of sediment. The potential for Ballycon bog being a sediment source to the external drains during proposed PCAS activities is considered moderate due to the absence of silt ponds at three discharge point. In addition to the cessation of peat harvesting.

The land use was assessed within the study area. The majority of land is peat bog. The remaining areas of the study area consist of pasture, transitional woodland-shrub and discontinuous urban fabric. The land provides important services such as food production, timber production, carbon storage, industry, biodiversity and habitat creation.

Table 2.2 summarises the constraints, risks and opportunities identified as part of the baseline assessment.

Table 2-2 Potential Opportunities / Constraints

Land Parcel / Feature	Risk or Opportunity?	Details
Agricultural land	Constraint	It is important to maintain the productivity of agricultural land surrounding the bog
Peat bog	Constraint	The adjacent peatland is in the possession of BnM. The impact from Ballycon bog should be considered.
Roads	Constraint	Minor roads providing access to dwellings, agricultural land and peat bogs are located in the study area. Access to these roads should be maintained.
Rivers	Constraint	The Philipstown river, the Daingean river and the Figile river are downstream of Ballycon Bog. No activity should adversely impact this area.
External drains	Risk	Risk of deposition in the drains is considered high due to potential sediment sources in adjacent lands and features within the external drains. External drains may be sensitive to change. Risk of reduced flows in drains.
Bog rehabilitation plan	Opportunity	To improve water quality discharging from the bog; stabilisation or improvement in water quality parameters (e.g. suspended solids)
Bog rehabilitation plan	Opportunity	To reduce carbon emissions from the bog and to set bog on a trajectory towards naturally functioning peatlands habitats. Ballycon has potential to develop embryonic Sphagnum-rich vegetation that has potential to be a carbon sink.
Bog rehabilitation plan	Opportunity	To improve biodiversity by vegetating bare peat and creating more habitat for flora and fauna.
Bog rehabilitation plan	Opportunity	To reduce runoff and restore a more natural runoff regime, thus contributing to flood risk management.

3 BOG REHABILITATION PLAN

The measures identified for the bog rehabilitation plan are detailed in the Rehabilitation Plan report.

Each measure while designed to promote the rehabilitation and re-wetting of the bog will have a potentially positive and/or negative impact on the adjacent land. This section identifies and assesses these potential impacts.

3.1 Impact Screening

Table 3.1 summarises the rehabilitation measures proposed for the Ballycon Bog and their potential impact to adjacent land.

Table 3-1 BRP measures proposed at Ballycon Bog

BnM rehabilitation measure	Description	Potential Impact	Potential Impact Description
Drain blocking, berm.	Existing production field drains within the bog areas that convey surface water away from the former peat production fields towards the bog discharge points will be modified to reduce conveyance or removed altogether by infilling. Surface water runoff through the bog will be slowed allowing the bog to store more water	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream. Reduced conveyance at bog inflow point resulting in increased water volume in external drain located upstream if conveyance channels through the bog are blocked.
Blocking outfalls	Most production field drain systems drain into a headland pipe running perpendicular to the peat field. This intersection is known as an outfall. By blocking the outfalls each production field drain will be prevented from operating resulting in the ditch storing water and raising the water table level in the bog. This will allow the bog to store more water and bring the water table level to the surface.	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream. Raised water table levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Water table levels in lands within this hydraulic gradient will potentially rise. The effect will be greatest immediately beside the bog.
Managing overflows with overflow pipes	This measure is usually combined with blocking outfalls which cause water table levels to rise. As the bog fills up it will want to overtop at the lowest part of the bog boundary. Overflow pipes control the location this occurs and where the overtopping water is discharged to.	Neutral	The control features will determine the location of the discharge from the bog. However the flow leaving the bog once it is full will be the same as prior to remedial works. Overall the volume of water discharging from the bog will be reduced but will contribute to raised water table levels within

			the bog and potentially within the zone of influence (subject to mitigation).
Sphagnum moss inoculation	This measure will propagate sphagnum moss within the bog. Sphagnum moss will cause bog regeneration as it grows and layers.	Positive	Sphagnum moss can hold up to 10 times its weight in water. As such this measure will store water reducing the runoff from the bog into the exterior drains. This will help retain the external drainage efficiency which adjacent land relies on. This measure may also contribute to runoff reduction and wider catchment FRM goals but in a piecemeal way.
Silt ponds	Existing silt ponds will be maintained to store runoff water from the bog and allow any suspended peat to settle out of the water before it is discharge to the external drains.	Neutral	Maintained capacity from the bog discharge points to the external drains and river located downstream. Maintained quality of water being discharged from the bogs into the external drains or river.
Wetland creation	Areas prone to flooding and depressions on shallow peat are designated for wetland creation. Shallow standing water will be allowed to occur resulting in increased water storage. Establishment of reeds and other rhizomes will form part of the wetland creation.	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains and river located downstream.

3.2 Impact Assessment

Three potential impact sources were identified; water table rise, increased runoff from the bog and low flow risk. These impact sources have the potential to make the adjacent land wetter and drain less efficiently or reduce water supply in adjacent drains. An assessment was carried out to delineate the zone of influence resulting from these potential impact sources. Figure 3.1 presents the areas which are at potential risk.

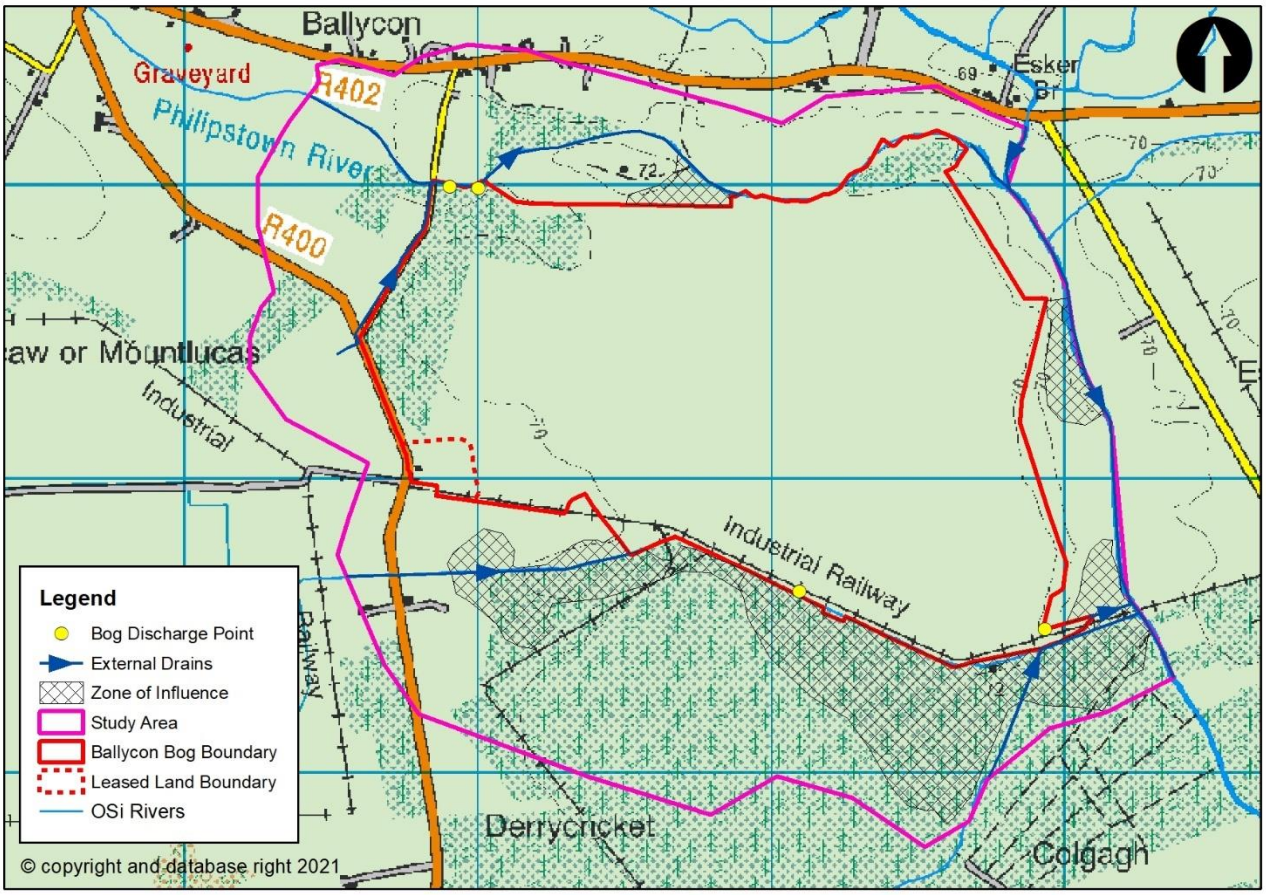

Figure 3-1 Ballycon Bog Rehabilitation Plan- Zone of Influence

3.2.1 Water Table Impact

The impact of rehabilitation measures on water table levels within and adjacent to the bog is difficult to assess quantitatively in the absence of long term monitoring data and hydro-geological models of the bog. Nevertheless, it can be assumed that water table levels will rise within the bog itself given that this is an objective of the rehabilitation measures – to restore the hydrological conditions for peat formation. It can also be assumed that the maximum level which the water table will reach outside areas zoned as wetland is the surface of the peat fields post-rehabilitation. This is because topographical flow paths for surface water out of the bog (by gravity) will be retained. The construction of a berm and drain blocks during previous restoration works which took place in 2005/06 raised the water table and caused increased ponding in the northern section of the bog. Whilst this work has had no impact on adjacent lands the water depths in some areas appear deeper that desired therefore water levels are to be reduced here by piping and notching weirs in the existing

berm to ensure drainage to the south is maintained. For areas zoned as wetland the maximum water level will be at or above surface level as shallow water ponding is promoted through rehabilitation measures.

The surface of the bog may lie higher or lower that the adjacent land. This relationship between the bog and adjacent land needs to be considered when assessing potential water table rise. Figure 3.2 show these two relationship scenarios. Where the bog is lower than the adjacent land it would be expected that the water table would remain lower on the bog side even when the water table is raised to the bog surface. If wetland areas are created and the water level is raised above the surface it may result in higher levels than the water table in adjacent lands. In this case the presence of a boundary drain can act as a hydraulic break bringing the water table down to its original level and preventing a rise in the water table in the adjacent land. Where the surface level of the bog is higher that the adjacent land the risk of raising the water table in the adjacent land is greater. However, in this scenario the presence of an effective boundary drain will collect runoff from the bog and act as a hydraulic break bringing the water table back down and preventing a rise in the water table in the adjacent land.

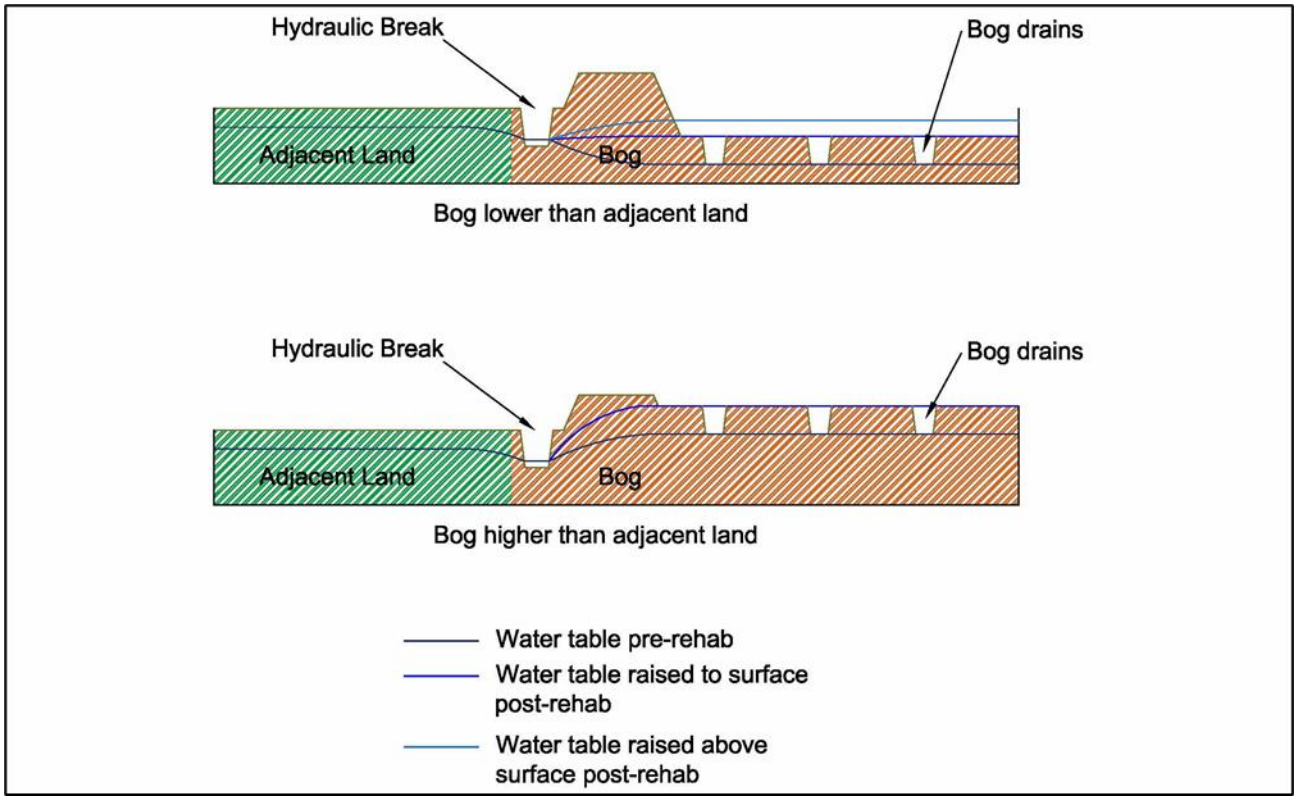

Figure 3-2 The effect of water table rise due to bog rehabilitation

For Ballycon Bog the adjacent land lies lower than the bog in some locations, identified in Figure 3.1 as the Zone of Influence, and higher in other locations. Water table rise in lands adjacent to the Ballycon was assessed firstly by estimating the potential rise in water table within the bog. The drainage system in the bog is typically 0.6m deep. It can be expected that the water table would rise by 0.6m to bring it to the surface. A cross section was surveyed, as shown in Figure 3.3, to assess the potential impact of a water table rise.

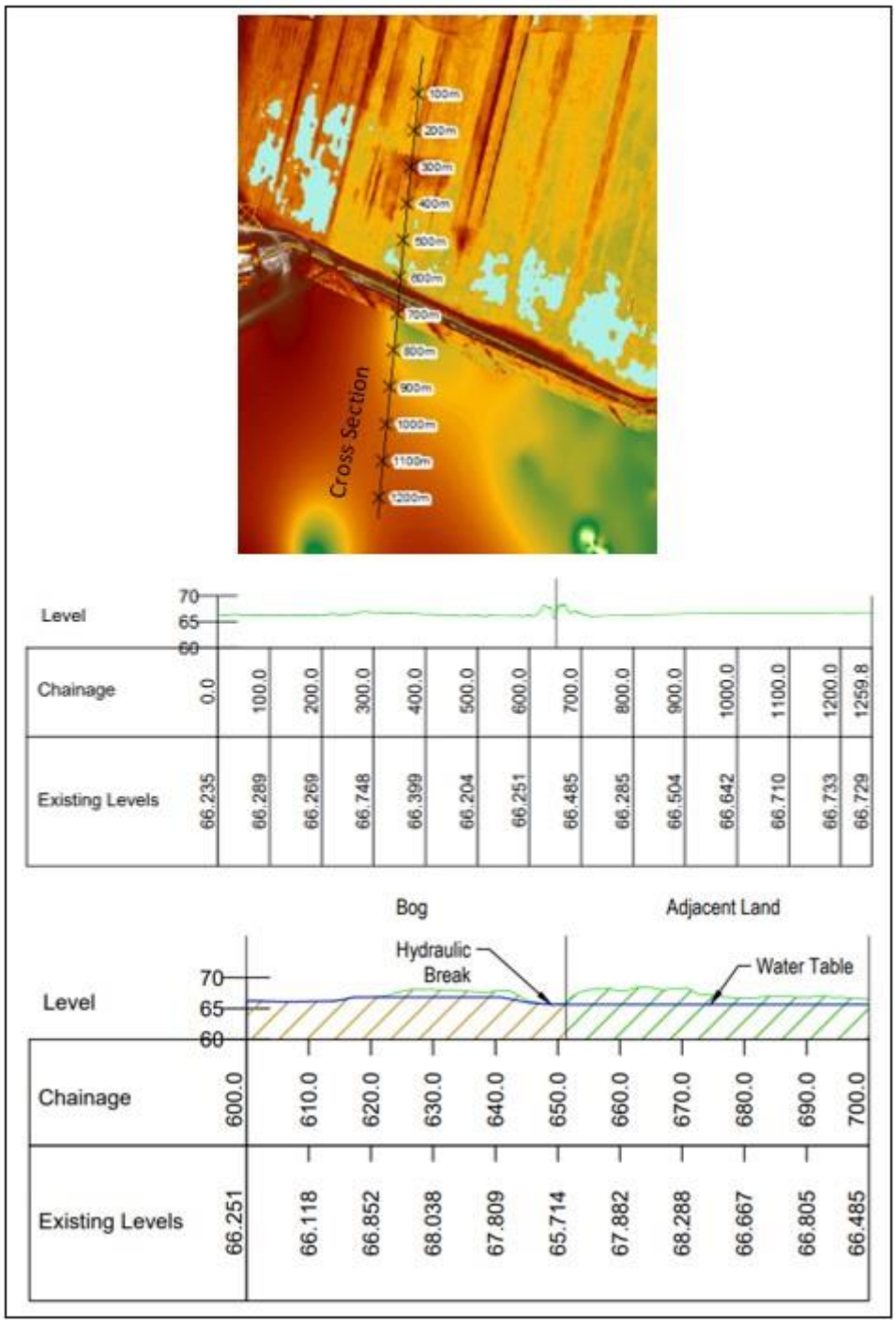

Figure 3-3 Conditions affecting water table

The cross section shows that a rising head in the bog would create a hydraulic gradient across into the adjacent land with the potential for a raised water table in the adjacent land also. This action determines the zone of influence and the areas of potentially wetter ground. The presence of boundary drains however will act as a hydraulic break controlling the hydraulic gradient and reducing the zone of influence. As these boundary drains lie lower that the adjacent land it is expected that they will function as a hydraulic break. This however is dependent on the drain's ability to adequately convey flow.

Drains that are inefficient with high water levels (independent from the bog rehabilitation measures) will also raise the water table in the bog and potentially in the adjacent lands to the bog would be wet. The avoidance of the drain full condition is dependent on the retention of a positive gravity drainage function of the boundary drains the adequate functioning of which is maintained.

Boundary drains were identified by aerial imagery and lidar for Ballycon, which provide the water table cut-off function to agricultural lands. It is assumed that these drains would be able to convey Q_{med} (2 year return period) flows under non-backwater conditions which would be typical of natural watercourses in Ireland. Therefore under non-flood conditions it is expected that the external drains identified around Ballycon Bog will act as a hydraulic break to any hydraulic gradient created by bog re-wetting. However there is a risk that should the flow regime in any external drain be changed post rehabilitation that the land adjacent to the drain would become wetter.

Caution should be exercised during any alterations of boundary drains around Ballycon Bog. As described in section 2.3, the peat overlays permeable bedrock. It is important to avoid the creation of new flow paths into the bedrock which has the potential of increasing water table flood risk elsewhere or altering the hydrogeological conditions for peat formation. If deepening of drains is undertaken it should therefore be undertaken with care so as not to deepen the drain beyond the base of the peat.

There is also a risk that as the bog fills with water and wants to discharge, and that unintended discharge locations would occur. A review of the bog boundary was carried out. No low points were identified that may become an unintended discharge location. Ballycon Bog discharges directly to the Philipstown River to the north where it meets the Daingean river north east of the bog. The bog also discharges via adjacent land drains to the south to the Daingean River a Tributary of the Figile River. There is little risk to adjacent lands from increased flows from the bog owing to elevated water table levels. As previously set out this is dependent on existing boundary drainage network isolating the bog from lower level adjacent lands and providing a positive gravity drainage function. In other words capacity to convey Q_{med} or 2 year return period flows and a free flow (constantly falling) away from the bog.

3.2.2 Increased Runoff

Evidence from bogs that have previously been the subject of restoration measures demonstrates that the measures proposed at Ballycon, which are all aimed at reducing runoff and retaining water within the bog, have the effect of reducing the frequency and magnitude of flood events by restoring a more natural hydrological regime. Restoration / rehabilitation has been successfully applied to numerous Bord na Móna bog sites as well as SAC sites such as Clara Bog (East), Raheenmore Bog, Carrownagappul Bog and Lisnageeragh Bog. Elsewhere, the restoration of peatland catchments in numerous sites across the UK, such as Exmoor National Park in Snowdonia, has demonstrated positive flood alleviation as a result of following rehabilitation measures and monitoring has shown reduced runoff from the moorland as a result of increased storage in the peat.

The risk of increased runoff from Ballycon Bog is low. All rehabilitation measures being proposed will reduce runoff. However, there is a potential that if bog re-profiling is carried out as part of the bog rehabilitation measures that the bog sub-catchments will be modified. Changes in sub-catchments could result in certain

discharge points draining larger areas. This would result in increased flows that could outweigh the effect of the reduced runoff arising from the rehabilitation. This is a moderately low risk at Ballycon as the re-profiling of the bog, if carried out, will generally result in the same topographical flow paths, catchment watersheds and discharge locations as in the pre-rehabilitation state. Similarly, the effect of reducing or turning off the pumps at discharge points could result in raised water levels and a transfer of water across sub-catchments leading to increased runoff through other discharge points. This would be a low risk provided the alteration to the pumped discharge points allow for continued discharge and for ponding within the bog if necessary, to store the runoff. In the absence of a full pre and post rehabilitation runoff model and a precautionary approach has been adopted to ensure that all drainage infrastructure from the bog is retained and is fit for purpose.

3.2.3 Low Flow Assessment

A low flow risk assessment was completed to identify whether any discharge locations from the bog are at high risk of low flow during periods of low rainfall and high evapotranspiration. While it is anticipated that rehabilitation will generally lead to dampening of peak flows and support sustained flows during dry periods, there is a potential risk that during prolonged dry periods that the rehabilitation measures may lead to downstream watercourses drying out as a result of increased infiltration, increased rates of evapotranspiration along with the additional storage capacity created within the bog.

A high level risk assessment was carried out to identify the particular discharge locations where this may be a risk. The following are considered the key factors that are most likely to influence the risk of drains previously unaffected experiencing low flow:

1. The contributing catchment area to each discharge location (as this is one of the main factors that will influence the range of flow rates);
2. The intensity of the rehabilitation works within the catchment (both in terms of measures proposed and proportion of the catchment undergoing rehabilitation)

The larger the contributing catchment area it is considered less likely that a drain will be to dry out, while the more intensive the rehabilitation works the more likely a drain will be to low flow. In order to simplify the risk assessment process three risk categories (High, Moderate and Low) were identified for catchment area and restoration intensity based on experiences from other bogs where this issue has occurred. For rehabilitation intensity the proportion of the catchment area undergoing rehabilitation was used as an indicator of risk. The overall risk category assigned is determined based on Catchment area risk multiplied by Rehabilitation intensity risk as summarised below:

Table 3-2 Parameters of Catchment Low Flow Risk

Risk category	Catchment area (ha)	Rehabilitation intensity (% of catchment area)	Overall risk category
Low (1)	>20	<30%	Low (1-3)
Moderate (2)	5-20	30-60%	Moderate (4-6)
High (3)	<5	>60%*	High (7-9)

*Note: Rehabilitation intensity (% of catchment area) capped at Moderate for where the rehabilitation measure only involves drain blocking on vegetated high bog (MLT2)

Where any discharge locations are identified as high risk, it is recommended that Bord na Móna undertake a review of the drainage channel downstream of the bog to identify the potential impact to the land owners.

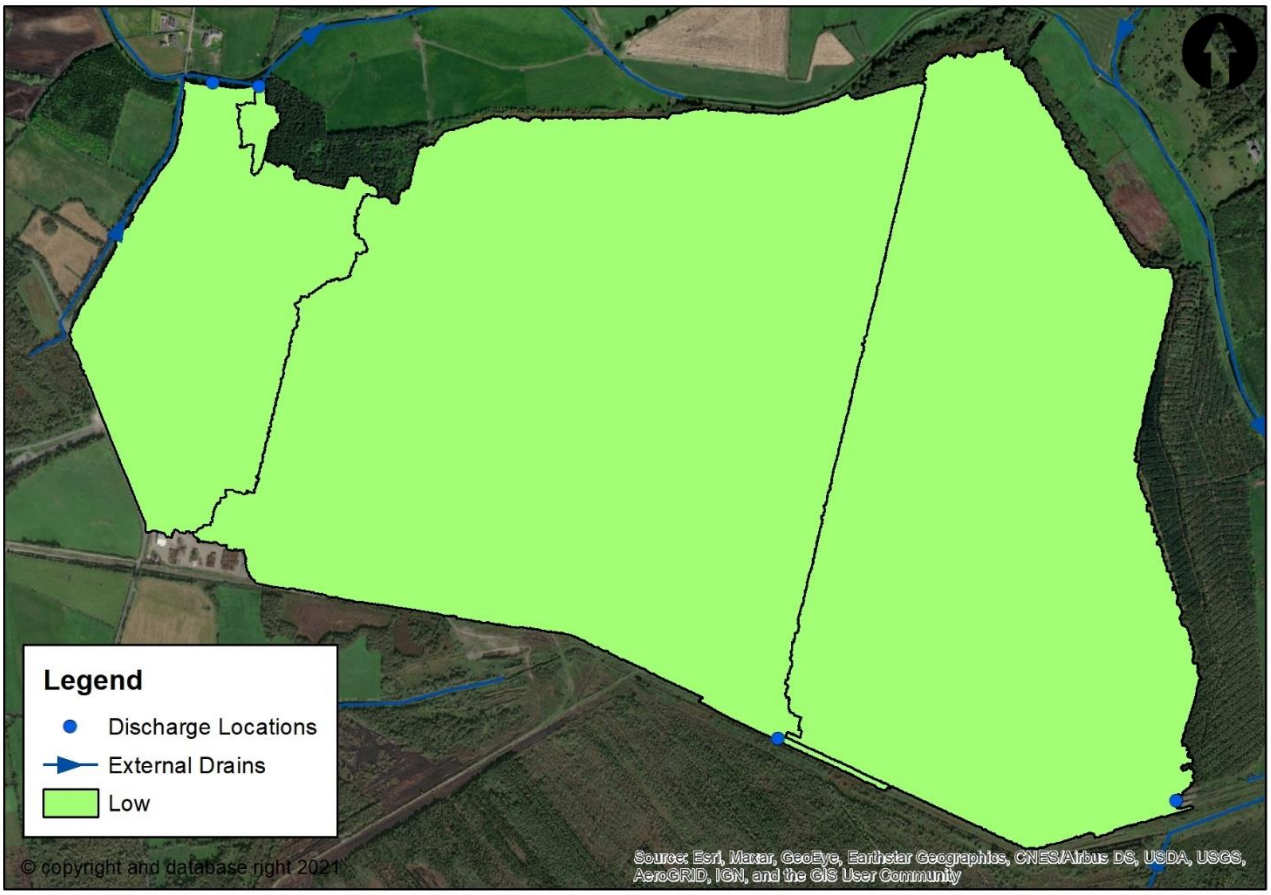

Figure 3-4 Overall Catchment Risk

Through assessing the catchment areas and rehabilitation intensity, all catchments were classified as low risk. No high risk catchments were identified that would require further survey and assessment.

3.3 Potential Risk Areas

The following assets have been identified as being at potential risk from flooding or wetter conditions as a result of measures described in Table 3.1 being implemented.

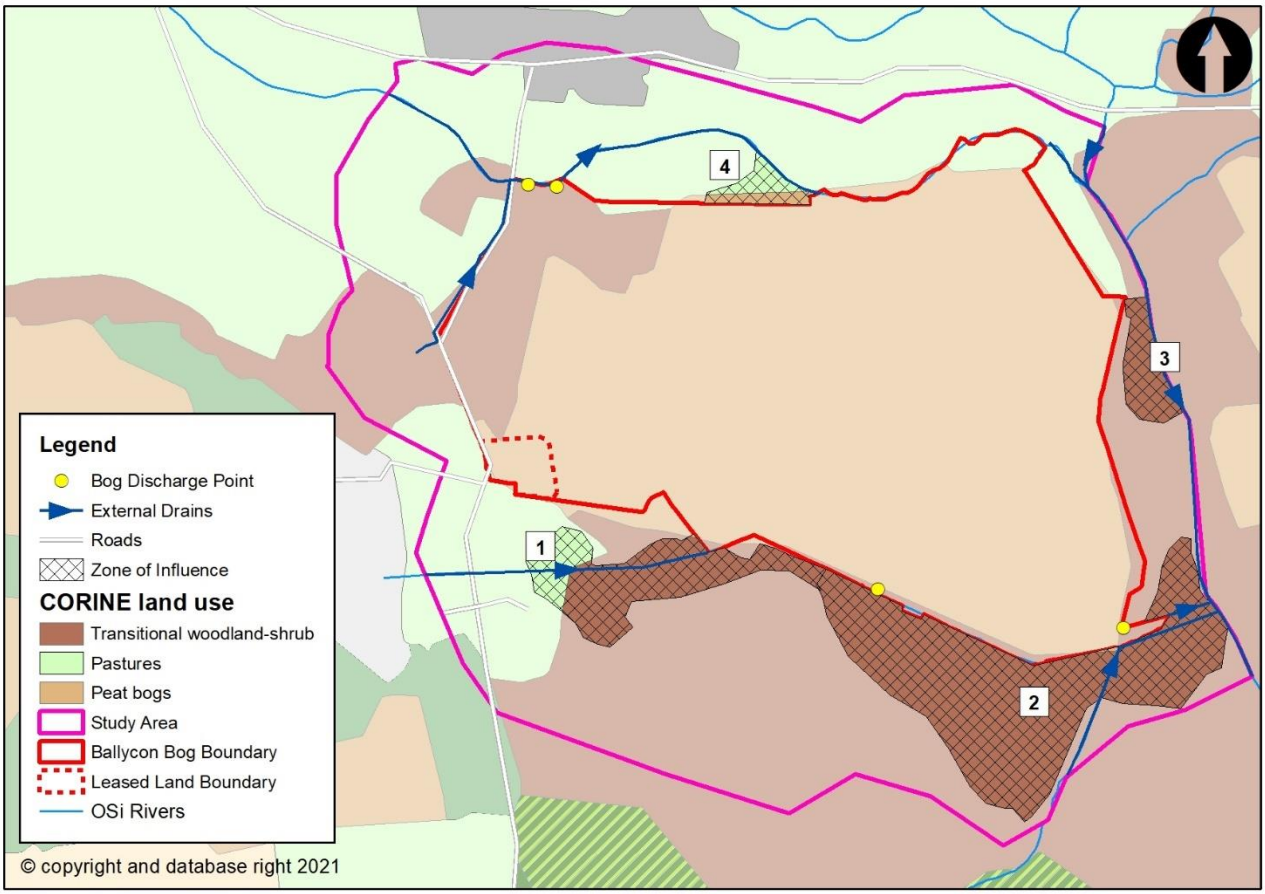

Figure 3-5 Ballycon Bog Rehabilitation Plan- Assets at risk

The assets at risk are set out in Table 3.3 along with the vulnerability, based on the current landuse, of the asset. It should be noted that the appraisal of the assets at risk considers the consequences of flooding or wetter conditions, not the likelihood of flooding or wetter conditions occurring.

Table 3-3 Assets at Risk

Item	Asset	Vulnerability to flooding and/or wetter conditions
1	Agricultural land	High Vulnerability. Agricultural land would become less productive should it be made wetter.
2	Woodland	Low Vulnerability. Woodland could tolerate wetter conditions and this area is within an adjacent BnM Bog therefore it is acceptable that it could be made wetter.

3	Woodland	Low Vulnerability. Woodland could tolerate wetter conditions.
4	Agricultural land	High Vulnerability. Agricultural land would become less productive should it be made wetter.
5	Roads	Low vulnerability. Road level slightly higher than surrounding land. Risk of flooding is low.

In addition to the above risks there is a general low risk that should degradation of the bog boundary occur surface water could be released into adjacent lands.

4 OBJECTIVES

The overarching objective of the Ballycon Drainage Management Plan is to facilitate the rehabilitation of bog through management of potential adverse impacts to adjacent land and waterbodies. SMART[2] objectives were developed for the Drainage Management Plan that provides direction for the overarching objective. These objectives consider constraints, risks and opportunities that were identified in chapters 2 and 3 and are detailed as follows:

1. To manage potential water table impacts between adjacent land and Ballycon bog during and after rehabilitation measures.
2. To maintain or reduce flows released from the bog at the discharge locations.
3. To manage sediment entering the Philipstown river, the Daingean river, the Figile River during and after rehabilitation, these measures are to ensure compliance with current discharge limits in IPC Licence.

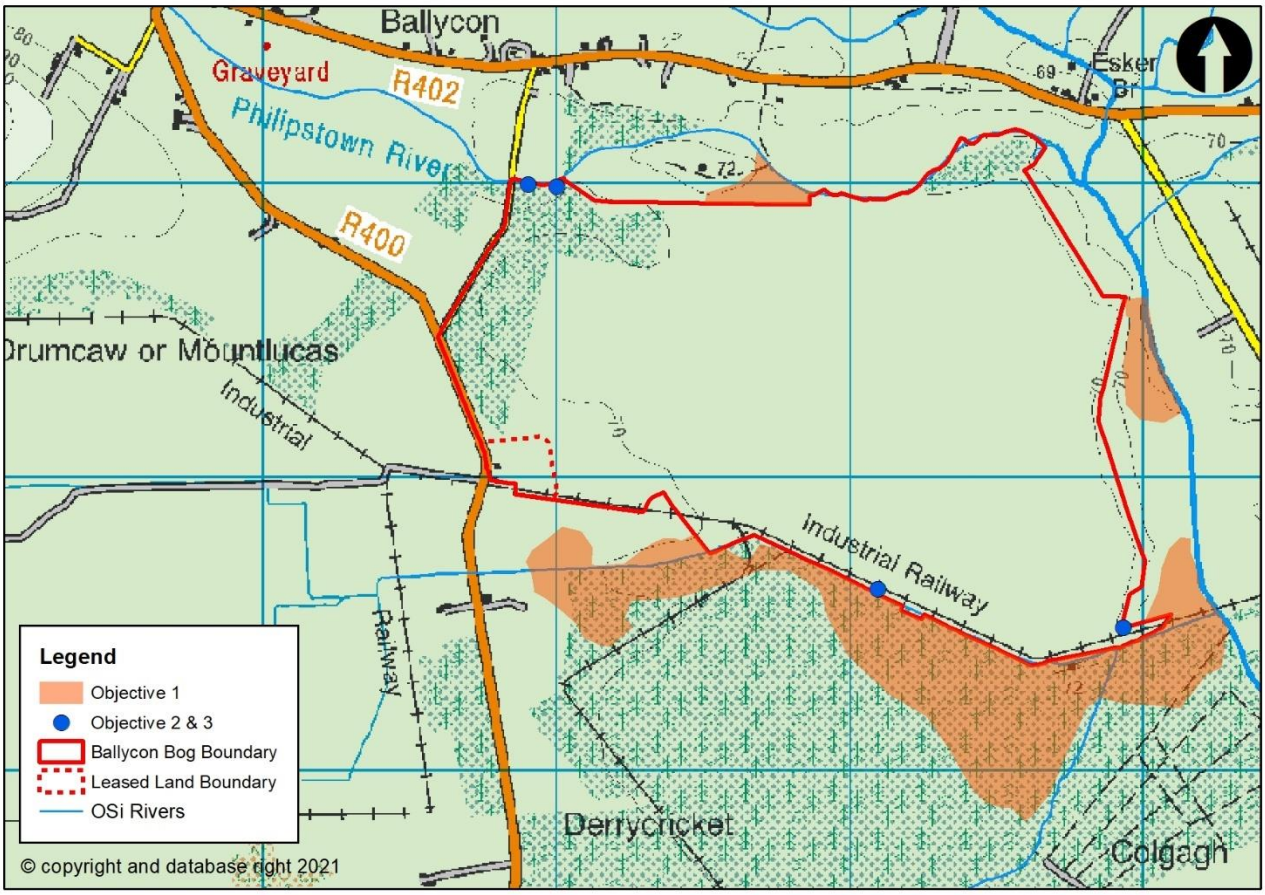

Figure 4-1 Ballycon Bog DMP objectives

[2] SMART – Specific, Measureable, Achievable, Relevant, Time bound

5 DRAINAGE MANAGEMENT MEASURES

5.1 Key Drainage Features

Drainage management measures were identified in relation to the objectives set in chapter 4 and are described below. Objective 1 considers the potential impact to adjacent land from water table rise. Objectives 2 and 3 consider the control mechanisms to flow discharging from the bog.

An assessment was carried out to identify the existing key drainage features available to meet the objectives set. Figure 5.1 presents the key drainage features identified. It can be seen in the figure that for water table level rise to be managed between the bog and adjacent land that a hydraulic break will be required where available. To ensure that the flow and sediment discharging from the bog is managed the discharge control points will need to be maintained.

Outside the Bord na Móna bog boundary key external drains were identified. These drains are hydrologically connected to the bog drainage network. While no drainage issues were identified along these external drains, see section 2.4, a risk of sediment deposition was highlighted from sources outside the bog. The maintenance of the existing silt ponds will mitigate the risk of sediment deposition arising from rehabilitation. Post implementation of the measures there will be in general a reduction in risk of sediment/silt escape once the bog reaches environmental stabilisation. It is noted that sediment deposition in the external drains could impede the drainage of the bog and adversely impact adjacent lands.

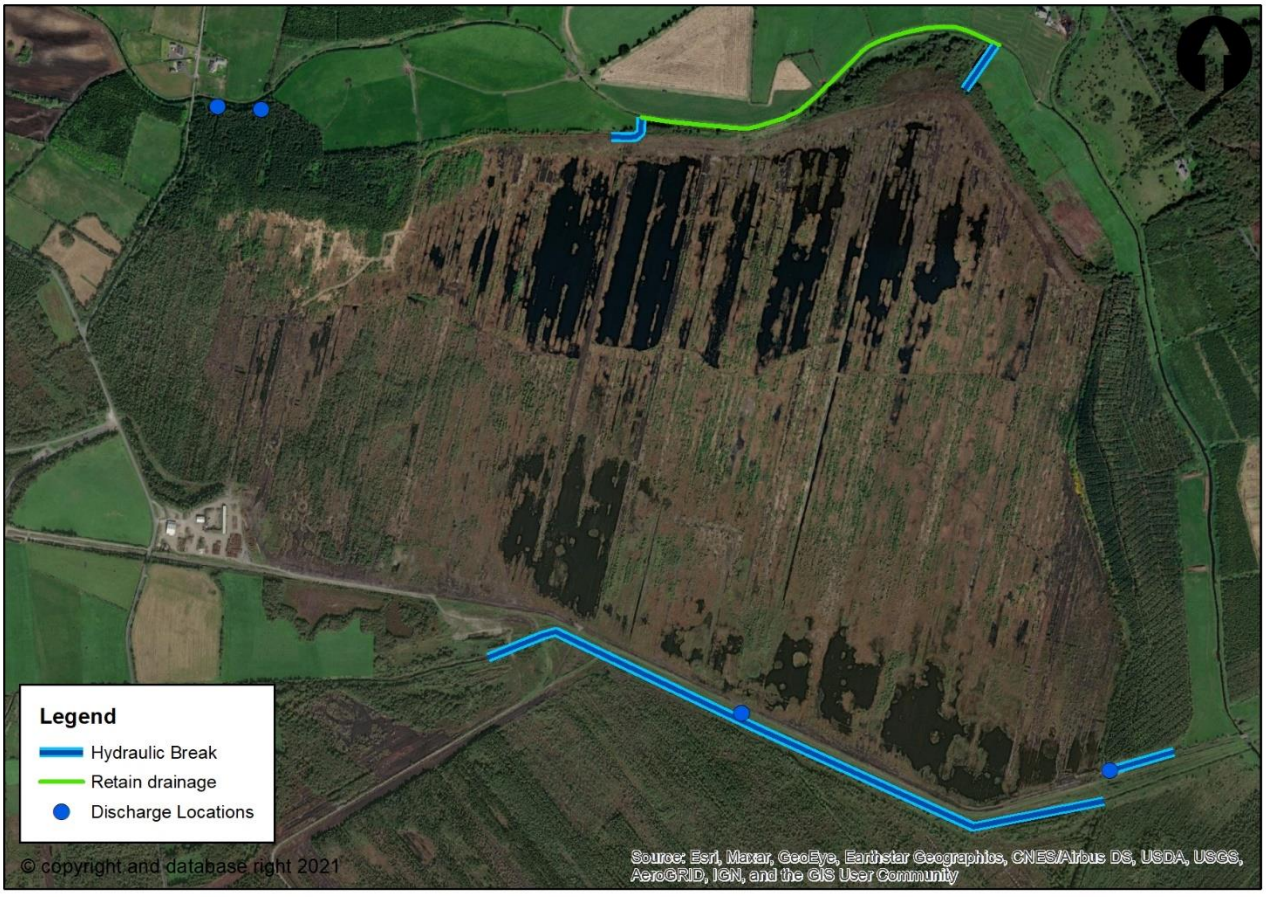

Figure 5-1 Key drainage features for Ballycon Bog

When identifying measures to provide the key drainage features a review was carried out of the drains. LiDAR, topographical surveys and local knowledge from Bord na Móna operatives were used in this review. While the review gave a good indication of the key drainage features' performance it is acknowledged that gaps in information or changes to features post survey could change the expected performance. Ballycon Drainage Management Plan therefore outlines a suite of responsive measures taking into account such factors as robustness and ongoing on-site observations. The Drainage Management Plan would therefore allow the bog to be managed and adapted as the rehabilitation plan progresses and is retained in the future. The following sections describe the suite of measures that can feasibly be implemented for the Ballycon Bog Drainage Management Plan.

5.1.1 Boundary Drains

Boundary drains can provide hydraulic breaks between the bog and adjacent land, see Figure 5.1. In most areas of the Ballycon Bog where hydraulic break would be required there are existing boundary drains. Available information indicate that these drains are suitable to provide hydraulic breaks and can be designated as such and retained in the future. Observing and recording the suitability of the boundary drains is recommended and where they are found to be not functioning as predicted upgrade works will be required. This would involve modification of the drain to make them larger/deeper/wider/steeper. This may be only in specific locations along the drain or an entire reach may require upgrading. Where there is no boundary drain present a new drain can be excavated in order to create the hydraulic break required. In these cases a channel of specified dimensions and slope will be required and where possible will not extend into the mineral soils (See section 3.2.1).

5.1.2 Bog Rehabilitation Modification

Where a boundary drain is not suitable to act as a hydraulic break or where none exists it may be possible to review the bog rehabilitation plan to provide the required mitigation measure. This can take the form of sacrificing rehabilitation of the last peat field, or equivalent rehabilitation area, closest to the adjacent land where an existing field drain could provide the hydraulic break function. The field's drainage network would be retained keeping the water table to current conditions and providing a water table cut-off in relation to the adjacent land.

In areas zoned as wetland within the rehabilitation plan control of the water levels may be required. Where there is a potential backwater into adjacent lands or where raised water levels could potentially raise water levels on adjacent lands setting a maximum control water level may be required. This control level will allow water to drain freely from the wetland area although water levels may rise higher than the control level during flood conditions.

5.1.3 Maintenance of Discharge Points

Existing silt ponds are located upstream of the bog discharge points. They help regulate the flow and ensure that's suspended solids are settled in the pond, maintaining compliance with the emission limit values regulated

by the EPA. Bord na Móna have legal responsibility to maintain these silt ponds and ensure their proper functioning capacity under the existing IPC Licence (Ref. P0500-01).

If alterations occur where no silt point exists upstream of a discharge point and no subsequent silt pond will be utilised before flow would leave the bog alternative silt control measures will be required. This can include blocking and or diverting the discharge point so that the relevant sub-catchment of the bog drains to a different discharge point with a silt pond. The rehabilitation plan can be adapted where required to allow proposed wetlands to act as a silt control measure.

5.1.4 Monitoring

As mentioned above DMP measures were selected based on level of certainty and on-site observations. The most appropriate measure was selected from a suite of measures representing varying levels of intervention. Monitoring of the measure and adjacent land will be required prior, during and after the rehabilitation measures. A monitoring programme can be implemented to observe the impact from the bog rehabilitation to the adjacent land. Monitoring would be observational where the condition of the asset in question is assessed in relation to present day conditions accounting for seasonal variability. Where negative impacts are observed other measures can be implemented that will establish a hydraulic break or other features with the same functional requirement. Otherwise monitoring should continue until environmental stabilisation.

5.2 Identification of Measures

The following section along with Figure 5.2 and Table 5.1 lists and describes the DMP measures for Ballycon Bog.

DMP 1. The boundary drains identified in Section 5.1 as key drains are proposed to act as hydraulic breaks. The boundary drains' ability to carry out this function is dependant on their condition and being free draining. Section 5.1 indicates how all boundary drains appear to be functioning sufficiently with no known drainage issues identified along the drains or in adjacent lands.

Topographical surveys, LiDAR and anecdotal evidence suggests that the boundary drains identified for retention are functional and can be used as drainage management measures. They would therefore be suitable to act as hydraulic breaks provided they are retained with their current estimated carrying capacity. If issues are identified during walkover surveys, a higher level of intervention, drain upgrade, can be applied in these locations.

DMP 2. Existing silt ponds would be required to be maintained.

DMP 3. DMP 2 refers to silt control. This can be achieved through careful sequencing of drain blocks relative to discharge points, re-routing during the construction or adapting rehabilitation measures to provide silt control.

DMP 4. No suitable boundary drain exists to act as a hydraulic break. An area of the bog should therefore be excluded to act as a buffer between the rehabilitation and the adjacent land or and existing drain would need to be retained.

DMP 5. DMP 5 Refers to a drain to be retained which is outside the bog boundary however it is a boundary drain of Derrycricket bog which is in the possession of BnM. The land between Ballycon Bog and the

drain is a known water sensitive environment. There would be no added value to any stakeholder therefore in creating a new drain along the Ballycon boundary.

DMP 6. DMP 6 is a drain within the bog to be retained. It will ensure flow from the north section of the bog, north of the berm, south towards the discharge locations.

Table 5.1 list the DMP measures identified for Ballycon Bog and where they sit within the suite of possible measures that could be taken.

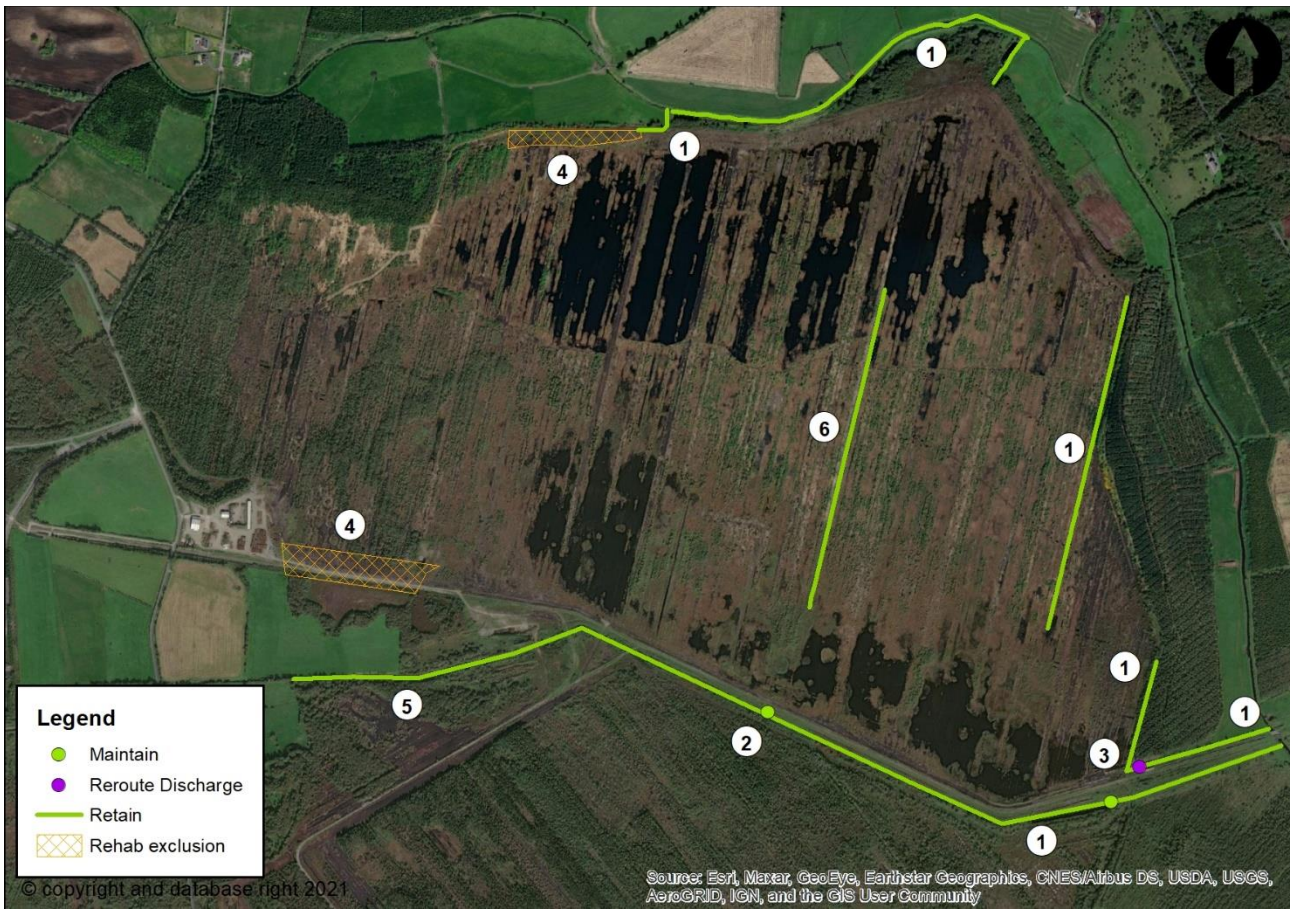

Figure 5-2 DMP measures for Ballycon Bog

Table 5-1 Selection of DMP Measures

Measures Item	Feature	Function required	Suite of measures Level of intervention			
			Low			High
1	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
2	Silt ponds	Silt and flow control	**Maintain pond**	Upgrade pond	-	-
3	Silt ponds	Silt and flow control	Maintain pond	**Upgrade pond**	-	-
4	Marginal land	Hydraulic break	-	-	**Retain drains in area of bog**	-
5	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain

5.3 Interaction with Monitoring Plan

As part of the bog rehabilitation plan groundwater level monitors have been installed at Ballycon Bog. These monitors will record water table and groundwater levels over the coming months. It will therefore be possible to ascertain if the water table is rising within the bog following the implementation of the rehabilitation plan.

This data should be considered during the monitoring measures of adjacent land. When water table levels are known to be rising within the bog, monitoring of the adjacent land (as described in Section 5.1.4) should take place on a more regular basis to ascertain if impacts to lands outside the bog are observed.

5.4 Residual Risk & Limitations

The level of flood risk to the bog and the surrounding lands has been shown to be low (Section 2.6) generally but with small areas of the bog susceptible to poor drainage and flooding. The impact of the proposed rehabilitation measures will generally be to reduce runoff from the bog but this will lead to increased water table levels and surface water flooding in the bog itself. During flood events no increase in flood risk is envisaged as a result of the rehabilitation measures. During normal low flow regime the Drainage Management Plan seeks to identify the measures that should provide a hydrological cut off between the bog and the surrounding lands.

As indicated in previous sections there are limitations to the assessments associated with the drainage network both within the bog and outside. Factors such as flow estimations of small catchments, lack of survey data limiting drain capacity estimations and high level definition of soil porosity all contribute to these limitations. Nevertheless the measures recommended represent a pre-cautionary approach based on conservative assumptions.

The DMP measures proposed set a baseline approach and a suite of measures in any given location has been provided. This will facilitate a reactive approach to be taken if required. In the event that a measure not be operating efficiently a higher intervention measure can and will be implemented. This will allow Bord na Móna to identify the most appropriate measure while proceeding with drainage function uncertainties.

5.5 Climate Change Adaptability

There is high uncertainty in relation to the effects of climate change, particularly in how it may manifest in terms of small catchment runoff. Ireland is predicted to have drier summers and wetter winters. The most appropriate guidance in an Irish context can be found in the OPW's Flood Risk Management Climate Change Sectoral Adaptation Plan[3]. For the Mid-Range Future Scenario, representing a central emissions estimate on a 100 year time horizon, it is recommended that allowances for peak flow and rainfall are increased by 20%. If such increases in runoff are realised over the timeframe of establishment of rehabilitation measures this could lead to a perception that bog rehabilitation measures at Ballycon are the cause of increased flood risk.

[3] Accessed on 10/12/2020 at https://www.gov.ie/pdf/?file=https://assets.gov.ie/46534/3575554721374f7ab6840ee11b8b066a.pdf#page=1

It is anticipated however that the rehabilitation measures will lead to reduced peak runoff as the water storage function of the bog is increased. This will serve to regulate peak runoff in winter and potentially smooth out the flows in drier periods, essentially acting against the anticipated effects of climate change.

It is therefore anticipated that the bog rehabilitation measures themselves will provide the mitigation of the effects of climate change on runoff and no additional measures will be needed. There are unknowns however in the effectiveness of the rehabilitation measures in this regard and also the severity of climate change impacts. Continued monitoring of the adjacent lands is therefore also crucial to gauge the effectiveness of the bog rehabilitation measures in mitigating these climate change impacts.

6 SUMMARY OF DRAINAGE MANAGEMENT PLAN

The Drainage Management Plan for Ballycon consists of a series of measures to be implemented at different stages of the rehabilitation process. Drains along the boundary were identified as hydraulic breaks in order to mitigate against any potential impacts from the bog rehabilitation measures. The effectiveness of all drains acting as hydraulic breaks is dependent on their ability to convey flow which have been outlined in Section 5.1 and deemed suitable subject to the measures recommended. Factors such as channel size and slope will determine this along with any downstream feature which may control water levels. The external drains which these boundary drains discharge into are also key drainage features that will affect the operation of the drainage network.

Measures will range from low intervention to high and consist of monitoring, retention of existing features, upgrading features. Maintenance of measures are proposed to the silt ponds within the bog to ensure that discharge from the bog and sediment is controlled. This is a legal obligation for Bord na Mona and will continue at all existing silt ponds.

Monitoring of adjacent land is included in the plan. The monitoring will observe agricultural land, adjacent bog, and woodland for adverse impacts from the bog rehabilitation. In the event that adverse impacts are confirmed, higher intervention measures can and will be implemented to mitigate the impacts.

Monitoring measures will therefore be ongoing during and after the bog rehabilitation measures. Continued retention and maintenance of the key drains and silt ponds will also be required after the bog rehabilitation measures. Throughout the process landowner engagement is recommended to ensure both the rehabilitation plan and Drainage Management Plan are understood and to promote collaborative working to manage impacts as they arise.

Table 6-1 Drainage Management Plan

Measures required PRE bog rehabilitation measures	Measures required DURING bog rehabilitation measures	Measures required POST bog rehabilitation measures
Landowner engagement if required via community liaison	Landowner engagement if required via community liaison	Landowner engagement if required via community liaison
Retention of boundary drains (see section 5.1.1)	-	-
Monitoring boundary drains (section 5.1.4)	IF REQUIRED – Consideration of need for higher intervention measures	-
-	Upgrade discharge point (see section 5.1.3)	-
Maintenance of discharge points (see section 5.1.3)	Maintenance of silt ponds (see section 5.1.3)	Maintenance of silt ponds (see section 5.1.3)
Monitoring of adjacent land (see section 5.1.4)	Monitoring of adjacent land (see section 5.1.4)	Monitoring of adjacent land (see section 5.1.4)
-	-	IF REQUIRED – boundary drain upgrades (see section 5.1.1)

-	-	Retention of key drains and pipes