BORD NA MÓNA - GARRYDUFF BOG

Drainage Management Plan

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EXECUTIVE SUMMARY

Garryduff Bog is located approximately 1km south of Shannonbridge in Co. Galway. The River Suck flows along the northern boundary and meets the River Shannon, which flows along the eastern boundary. Garryduff Bog is a pumped bog with a water table significantly lower than the surrounding area. The River Shannon and River Suck are immediately adjacent to the northern and eastern sides and parts of Garryduff Bog form part of the flood plain of these rivers. The bog is regularly inundated during winter and occasionally at other times when the water levels on the river are high.

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.

Three potential impacts were considered: the potential to reduce the drainage function to upstream lands, the potential for increased flows downstream and the potential for increased groundwater levels impacting adjacent lands. There is no potential for increased flows downstream and the rehabilitation of Garryduff Bog, based on evidence from other bogs, will reduce the runoff from the bog by returning the peatlands towards its natural water retention function. The level of the upstream land was considered suitably high to ensure a positive drainage into the bog even with bog rehabilitation measures in place.

The potential for increased groundwater levels and to a lesser extent marginal alteration of the topographical catchments has been assessed based on a precautionary approach. With wetlands being mainly proposed for Garryduff Bog it is expected that water levels will rise above the surface of the peat fields. In this scenario adjacent lands which are at a lower level than these parts of the bog could potentially be impacted. Vulnerable areas have been defined through a zone of influence approach.

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

DMP measures include controlling the water levels in the proposed wetland areas, excluding parts of bog fields from the rehabilitation plan. Retention of boundary and internal drains and upgrading of a boundary drain along one reach. Maintenance of existing silt ponds and monitoring.

A suite of measures was identified in order to mitigate any future deterioration to adjacent lands should monitoring of these lands indicate a groundwater or drainage impact on these lands from the bog. This approach accounts for unknowns and limitations inherent in this DMP study and provide a precautionary approach to drainage management.

1 INTRODUCTION

Garryduff Bog is part of the Blackwater Bog Group. Bord na Móna operated peat extraction within the Blackwater Bog Group under IPC Licence (Ref. P0502-01) issued and administered by the EPA. Condition 10.2 of this licence requires the preparation of a 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.

A key issue 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 groundwater 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 not well understood. Furthermore the increase in the local water table could result in negative impacts to surrounding lands if mitigation measures are not applied (e.g. to agriculture).

This Drainage Management Plan (DMP) for Garryduff 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 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.

1.1 Bog Details

Garryduff Bog is located approximately 1km south of Shannonbridge in Co. Galway. The River Suck flows along the northern boundary and meets the River Shannon, which flows along the eastern boundary. The surrounding landscape is a mosaic primarily consisting of low-lying agricultural land (pasture) interspersed with other raised bogs, many of which have also been managed by Bord na Móna for peat production with some areas utilised for domestic turf-cutting. Garryduff Bog is a pumped bog with a water table significantly lower than the surrounding area. The River Shannon and River Suck are immediately adjacent to the northern and eastern sides and parts of Garryduff Bog form part of the flood plain of these rivers. The bog is regularly inundated during winter and occasionally at other times when the water levels on the river are high.

A rail line connects Garryduff Bog with Kilmacshane Bog to the south-east and Lismanny Bog to the north-west. There is also a railway connection to the north-east, where the railway line bridges over the River Shannon to connect Garryduff Bog with the power station in Shannonbridge and other bogs around Blackwater, and a bridge over the River Suck to the north, connecting Garryduff Bog to other bogs in the Blackwater Bog Group on the Roscommon side of the River Shannon. There is also road access to the site alongside the railway line in the north and from a public road in the south-west. The only infrastructure on-site, apart from the rail links and associated machinery access roads and tracks, is a tea centre located at the northern end of the site next to Garryduff.

The site is bisected by one main railway line running roughly north-west to south-east and this is situated on the old route of the Ballinasloe section of the Grand Canal, which has been infilled.

Garryduff Bog was drained and developed for industrial peat production in the 1960s and has been in active peat production since 1968. Industrial peat production ceased in 2019. The peat harvested from this site was used for fuel peat in the West Offaly Power Station at Shannonbridge.

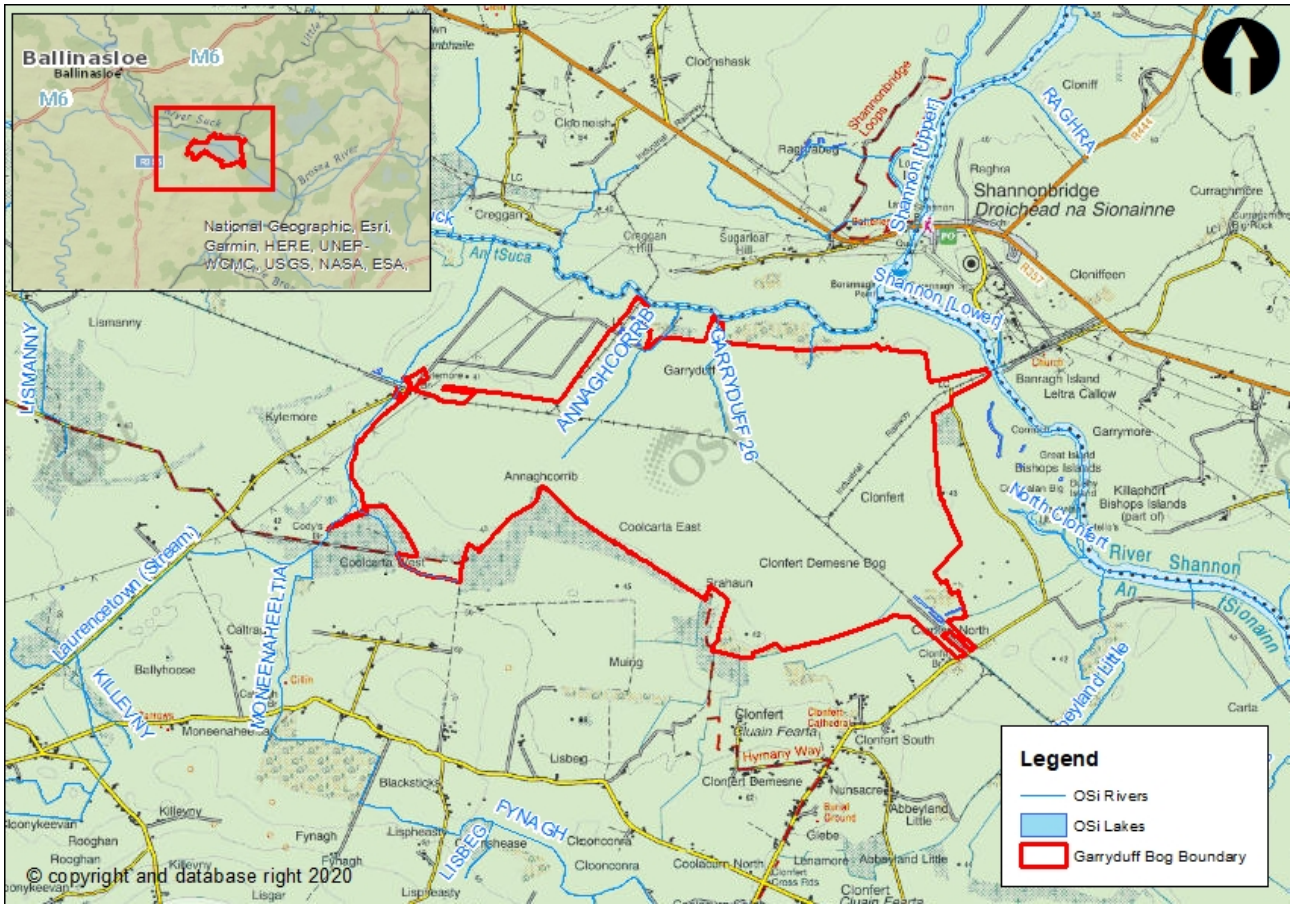

Figure 1.1 Location of Garryduff Bog

2 BASELINE ASSESSMENT

Through cessation of peat extraction and implementation of the Garryduff Bog rehabilitation plan there is the potential to 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 and adjacent lands through the bog. The drainage under the influence of Garryduff Bog discharges directly into the River Suck, a tributary of the River Shannon, or into external drains which flow to the River Shannon. 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.

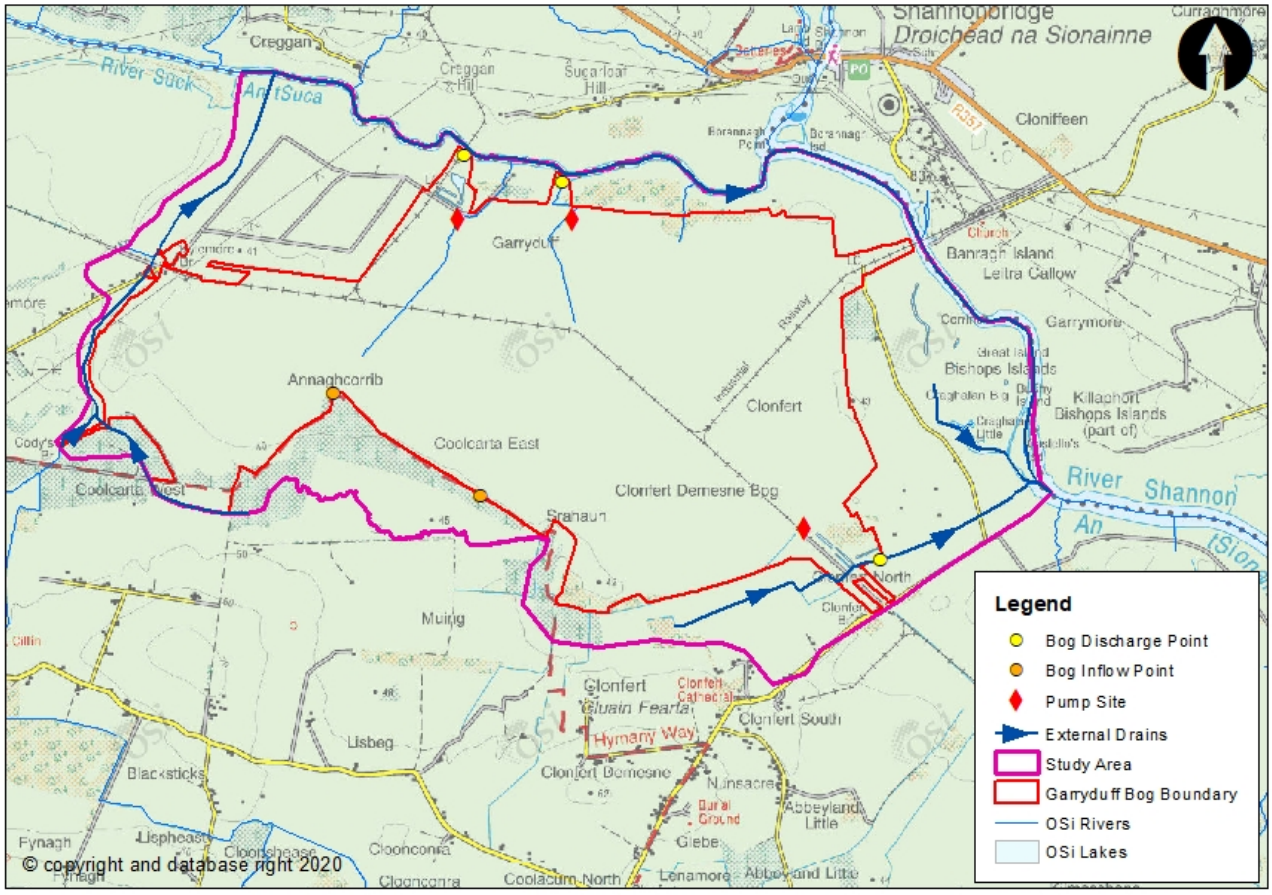

Figure 2.1 Study Area for Garryduff Bog

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. The recent Bord na Mona drainage survey was reviewed, and the bog sub-catchments confirmed. Sub-catchments of the external drains were identified using ARC GIS tools. The sub catchments are presented in Figure 2.2.

The 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.

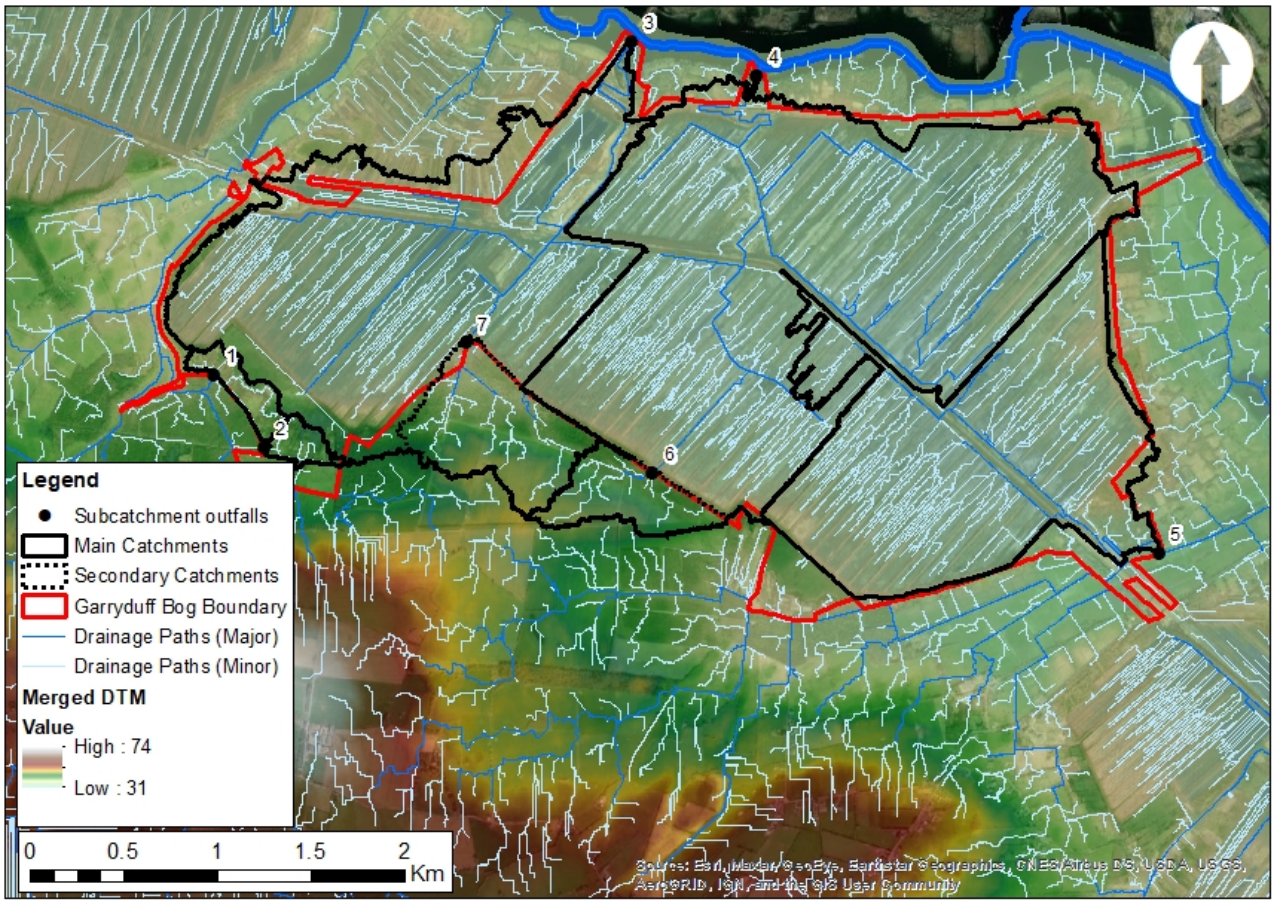

Figure 2.2 Drainage Networks and Sub-Catchments Draining Garryduff Bog

There are five main and two secondary sub-catchments draining Garryduff Bog and adjacent lands ranging in area from 0.06 km^2 to 4.48 km^2. The catchments are all subject to moderate / low amounts of annual average rainfall. The Baseflow Index for all of the catchments ranges from 0.561 and 0.653 representing a fairly permeable catchment. The catchments range from very flat to moderately flat.

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 (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	0.10	946.41	0.653	1	1.000	100.0	2.111	0.026	**0.036**
2	0.06	946.41	0.653	1	1.000	100.0	1.018	0.014	**0.024**
3	3.28	918.96	0.561	1	0.997	99.7	0.115	0.355	**0.813**
4	4.48	918.96	0.561	1	0.971	97.1	0.133	0.492	**1.063**
5	2.22	918.96	0.561	1	1.000	100.0	0.202	0.285	**0.581**

2.3 Hydrogeological and Soil Characterisation

Garryduff Bog and the surrounding area are underlain by dark limestone and shale bedrock which represents a locally important, moderately productive aquifer. Geological Survey of Ireland (GSI) tracing of karst features has identified Boreholes and Enclosed Depressions in close proximity to the bog. Nevertheless, the bedrock underlying Garryduff has potential to facilitate moderately high rates of baseflow / groundwater transfer. The soils covering the catchments are primarily peat, with some surface groundwater gleys and peaty gleys outside the extent of the bog and some mineral alluvium north and east of the bog. All of these soils would be considered to be moderately impermeable with the exception of the mineral alluvium on the floodplain which is considered highly permeable.

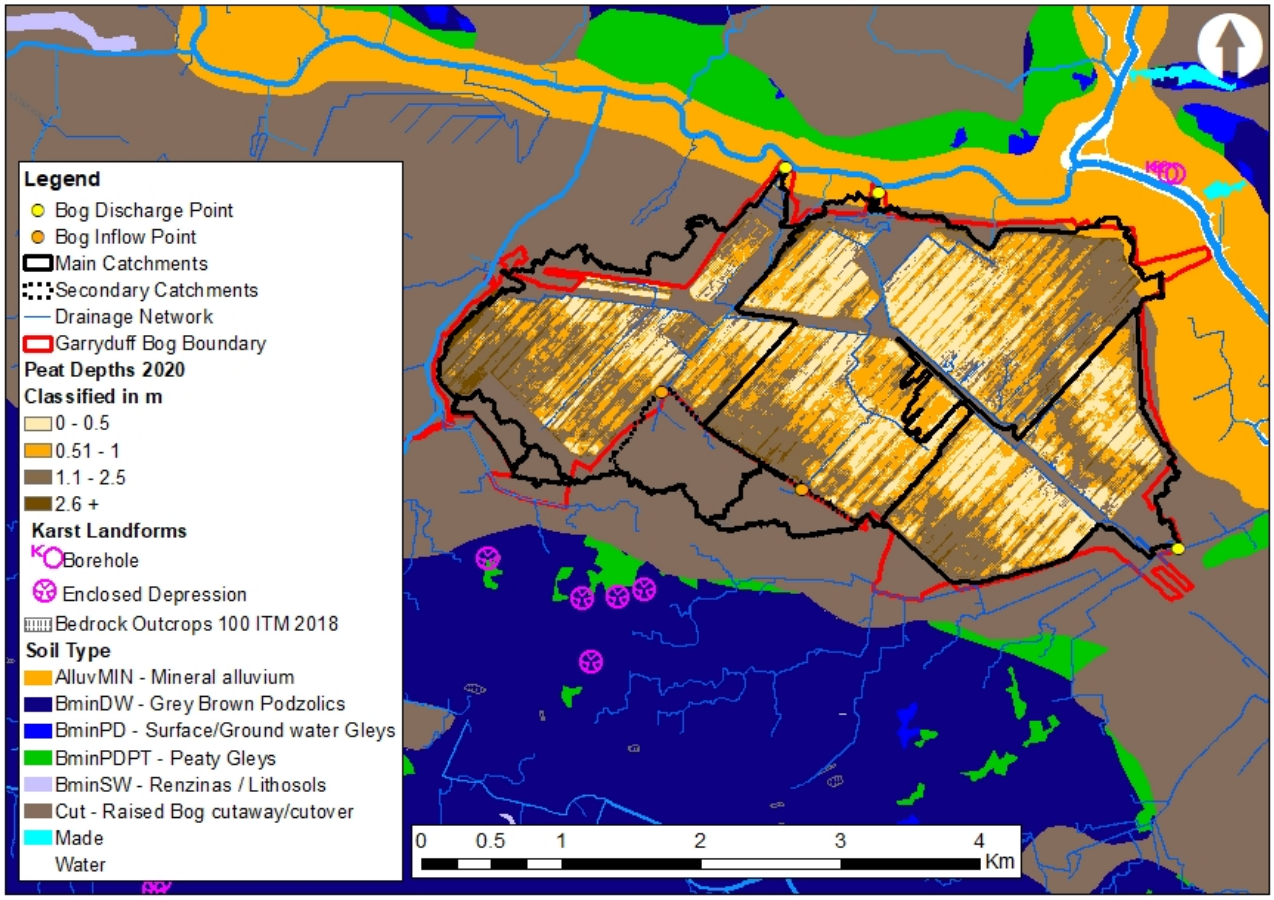

Figure 2.3 Hydrogeological and Soil Characteristics of Garryduff Bog

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. The River Shannon and River Suck are also external watercourses which represent very flat, large river reaches. 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 2.4 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 commercial forests and woodland in the surrounding lands there are existing potential sediment sources that could enter the external drains. These sediment sources are however considered minimal. Given the presence of culverts, channel widening, sharp bends and inflows along the external drains there would be a potential of sediment settling and deposition occurring should sediment sources be realised. The potential for Garryduff bog being a sediment source to the external drains is considered low due to the presence of silt ponds at all discharge points and that peat extraction activities have ceased.

A review of the bog drains was carried out. The Bord na Móna drainage survey details the open drains, pipes, pumps, settlement silt ponds and discharge points. All known discharge points have a silt pond located upstream which will reduce the amount of peat leaving the bog as water is drained. The drains in the bog have very gentle bed slopes and pass through numerous pipes before discharging from the bog. It would be expected that the bog drainage network would be sensitive to drain and pipe alterations and the two drains which receive inflows from the adjacent land, as shown in Figure 2.4, need careful consideration. A reduction in these drains' capacity may have the potential to impact on the agricultural lands that drain into the bog.

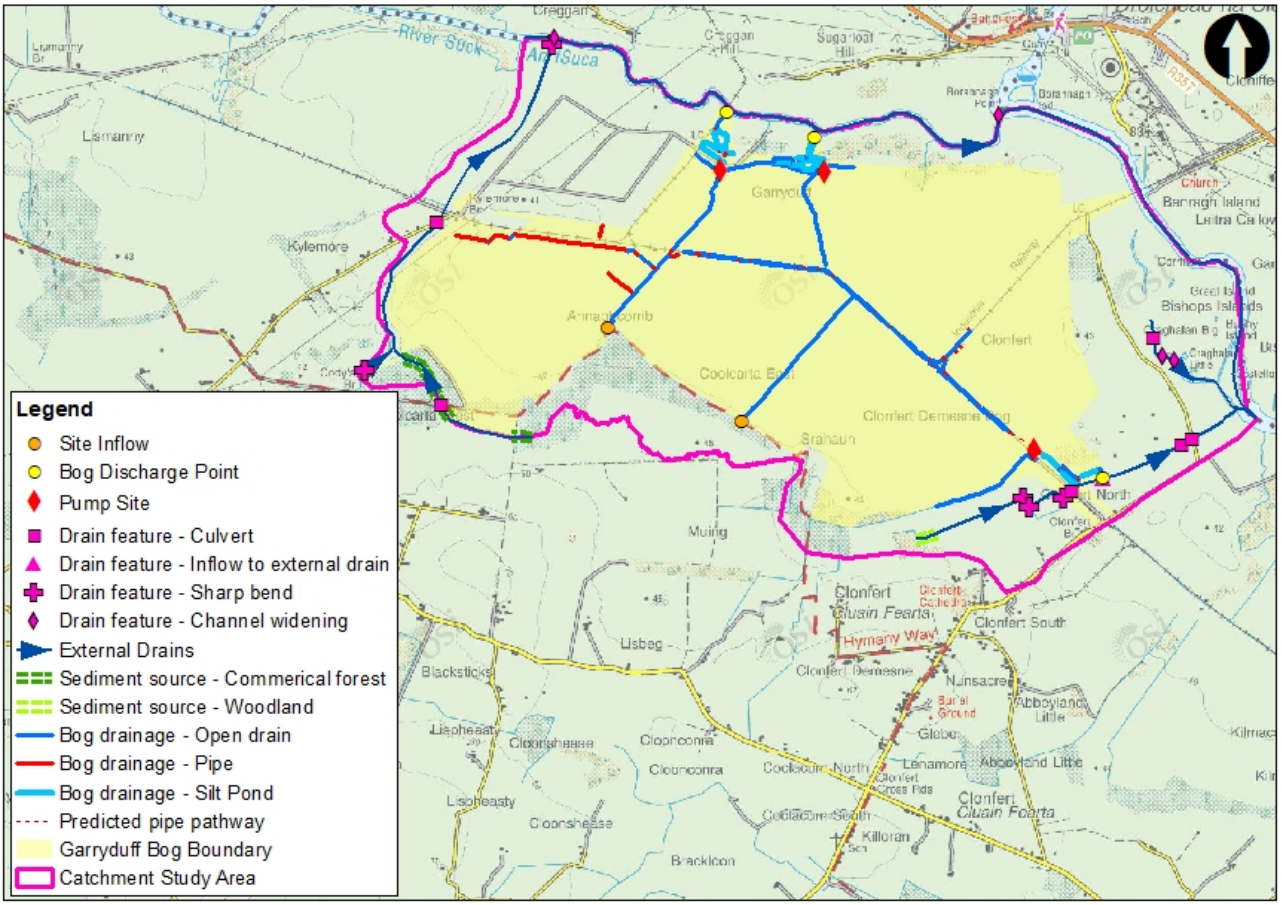

Figure 2.4 Morphological and Hydraulic Characteristics of Garryduff Bog and environs

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 less productive agricultural land with natural vegetation, coniferous forest, pasture and inland marshes. The CORINE land use dataset was used to identify landuse types. This dataset was then reviewed using aerial photography to establish landuse amendments or land use alterations. The review found no additional land use alterations. There are some minor roads and properties 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 majority of the peat bog outside the Bord na Mona bog shows evidence of being harvested for domestic fuel production. Other areas of peat bog are undisturbed which contribute to carbon storage and biodiversity. The woodland areas are likewise providing carbon storage and biodiversity albeit as a different habitat to the peat bogs. The minor roads within the study areas service individual properties and provide access to the pastures, forests and peat bogs.

In addition to the land use the River Suck corridor and the River Shannon corridor run adjacent to the Bog.

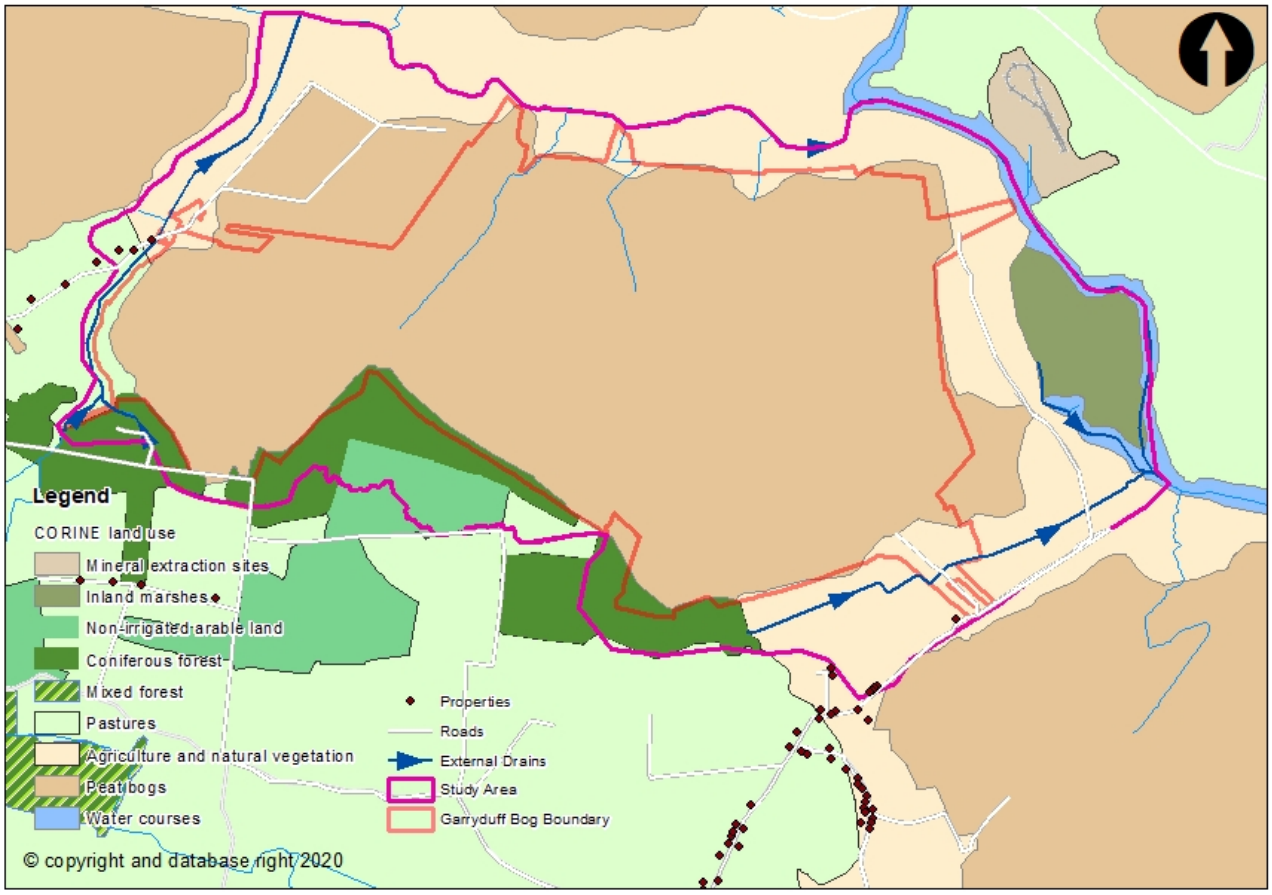

Figure 2.5 Land Use Characteristics of Garryduff Bog and environs

2.6 Flood Risk

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

- CFRAM Study maps setting out the predicted fluvial 10%, 1% and 0.1% Annual Exceedance Probability (AEP) fluvial flood scenarios for the River Shannon
- GSI predicted groundwater 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

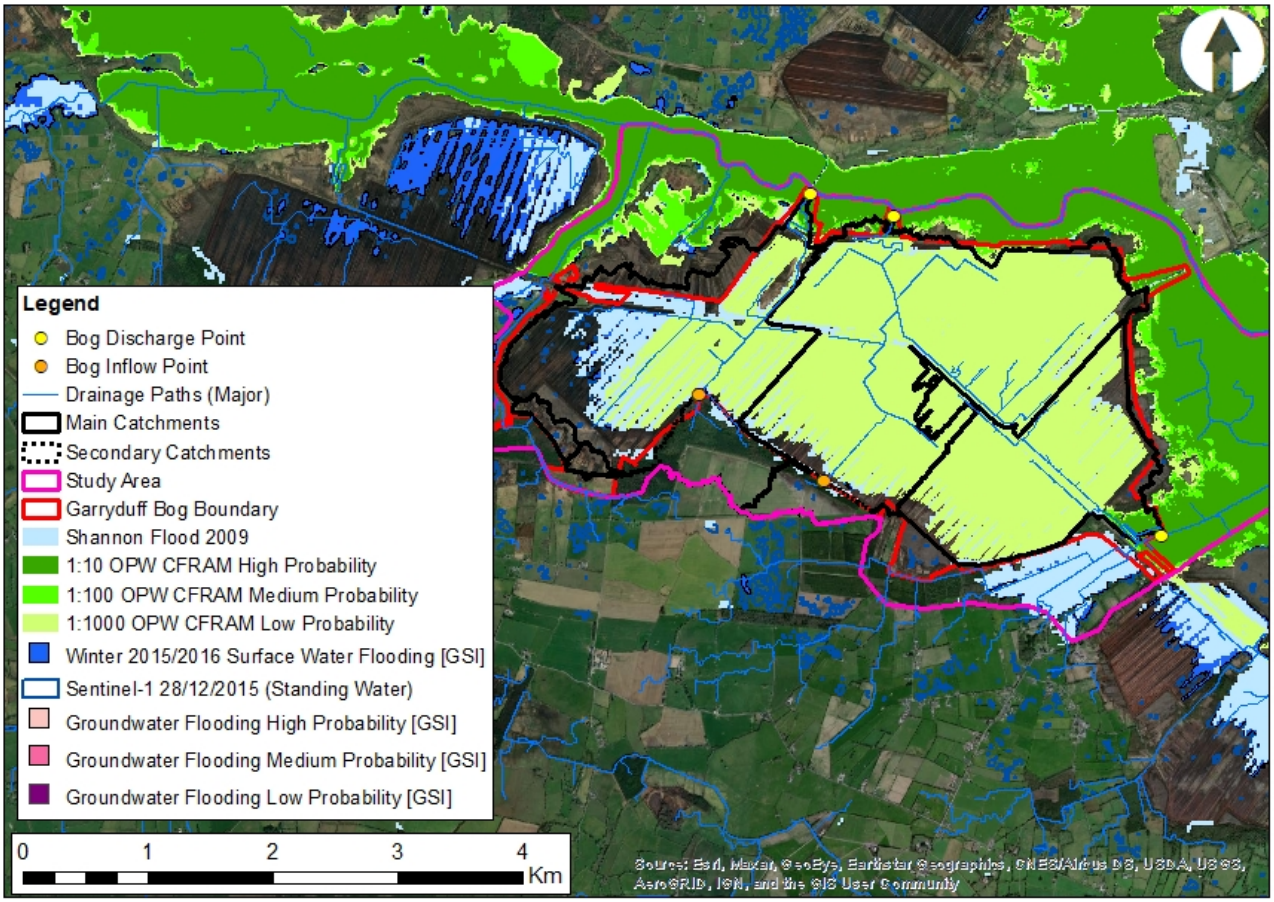

Figure 2.6 Flood Risk at Garryduff Bog

The 2009 and 2015 events on the River Shannon were very similar in magnitude with a peak water level of approximately 35.96m OD Malin recorded at the nearby Shannonbridge water level gauging station[1]. These are the largest peak water levels recorded in the 60 year record length at this gauging station and are estimated to have had a return period of just under 1 in 100 years. The mapped flood extents for the 2009 event are

[1] https://waterlevel.ie/0000026028/

shown to inundate most of the Garryduff site whereas a much lesser extent of the site is shown to be inundated during the 2015 flood event. This is likely due to embankment raising undertaken following the 2009 event rather than a significant difference in the severity of the events. Furthermore the flood extents observed during the events may also be driven to varying extents by surface water flooding / poor drainage. This is due to the bog lying within a hollow with a high ridge surrounding it. Drainage from the bog relies on pumps and when the rivers Shannon and Suck are in flood pumping is made more difficult resulting in water ponding within Garryduff bog rather than flooding from the rivers.

The CFRAM Study maps show fluvial inundation of the main peat fields from the Shannon and Suck only during a 1 in 1000 year return period event. It should be noted this analysis did not consider the fluvial flood risk from the smaller watercourses which drain to the rivers Shannon and Suck or flooding arising from surface water / poor drainage. 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 Garryduff Bog boundary drains. Data from the 2015/16 flood event indicates surface water flooding to the main peat fields and this is consistent with the local knowledge from Bord na Móna staff familiar with Garryduff Bog.

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

2.7 Summary

The drainage network sub-catchments within Garryduff Bog and its environs were used to delineate the study area for the Garryduff 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 the north section of the bog discharges to the River Suck. The south eastern sections of the bog discharge to drains which flow to the River Shannon.

The catchment area is considered to be relatively small, flat, fairly permeable with a low to moderate annual rainfall. Peak flood flows range from around 0.2 – 0.4 m^3/s per square kilometre (2 – 4 l/s per hectare) for the Q_{med} event to 0.7 – 1.1 m^3/s per square kilometre (7 – 11 l/s per hectare) for the Q_{100} year plus climate change event.

The bedrock within the catchment is dark limestone and shale. Geological Survey of Ireland (GSI) tracing of karst features has identified Boreholes and Enclosed Depressions in close proximity to the bog. The soil on top of the bed rock is mainly peat with some other soils in the higher ground. All soil types, with the exception of alluvium on the Suck and Shannon floodplain, are relatively impermeable which would restrict transfer of surface water to groundwater and vice versa.

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, inflows and channel widening were identified as potential factors for sediment deposition. Commercial forests and woodlands adjacent to the drains were identified as potential sources of sediment. Although the external drains are relatively flat and susceptible to deposition the potential sediment sources are minimal.

The land use was assessed within the study area. The majority of land is peat bog. Agricultural land with natural vegetation makes up a significant proportion of the study area also. The remaining land is made up of pasture and coniferous forest. The land provides important services such as food production, timber production, domestic turf cutting, carbon storage, 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	Where turf is still being extracted from other bogs adjacent to Garryduff Bog conditions should be not be made worse.
Roads	Constraint	Two minor roads are located in the study area providing access to a dwelling, agricultural land and peat bogs. Access to these roads should be maintained.
River Suck	Constraint	The River Suck corridor runs adjacent to the bog. No activity should adversely impact this area.
River Shannon	Constraint	The River Shannon corridor runs adjacent to the bog. No activity should adversely impact this area.
External drains	Risk	Risk of deposition in the drains is considered moderate due to potential sediment sources in adjacent lands and features within the external drains. External drains may be sensitive to change.
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. Garryduff 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 Garryduff Bog rehabilitation plan[2] consists of the following measures as summarised in Table 3.1 and presented in Figure 3.1.

Table 3.1 Garryduff Bog rehabilitation measures

Restoration	Description of measures
Deep peat restoration	Berms and field re-profiling (45m x 60m cell) + blocking outfalls and managing overflows + drainage channels for excess water + *Sphagnum* inoculation
Dry cutaway restoration	Regular drain blocking (3/100 m) + blocking outfalls and managing water levels with overflow pipes + targeted fertiliser treatment
Wetland creation	More intensive drain blocking (max 7/100 m), + blocking outfalls and managing overflows + transplanting Reeds and other rhizomes
	More intensive drain blocking (max 7/100 m), + field reprofiling + blocking outfalls and managing overflows + transplanting Reeds and other rhizomes
Marginal land restoration	More intensive drain blocking (max 7/100 m)
Other	Reduce pumping regime + maintain silt ponds

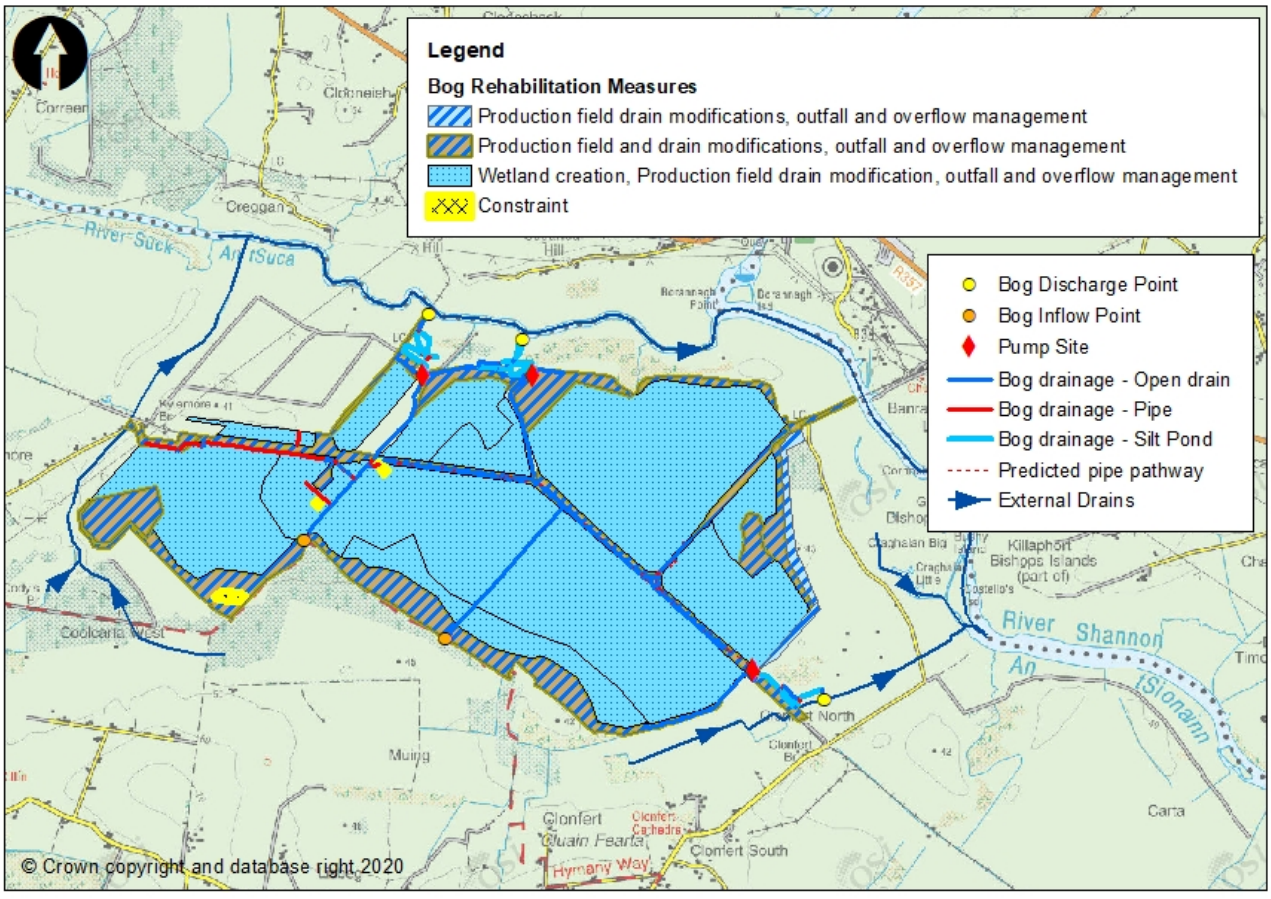

Figure 3.1 Garryduff Bog Rehabilitation Plan

[2] For further details see Garryduff Bog Cutaway Bog Decommissioning and Rehabilitation Plan 2021 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 Garryduff Bog and their potential impact to adjacent land.

Table 3.2 BRP measures proposed at Garryduff Bog

BnM rehabilitation measure	Description	Potential Impact	Potential Impact Description
Drain blocking, berm and field re-profiling	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 groundwater level in the bog. This will allow the bog to store more water and bring the groundwater 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 groundwater levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Ground water 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 groundwater 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 groundwater levels within the bog and potentially within the zone of influence (subject to mitigation).

Drainage channel for excess water	This measure will work in conjunction with the overflow features. Where suitable drainage channels do not exist or are of insufficient capacity along the bog boundary, a new or upgraded drainage channel will be provided. These drainage channels will convey all flows from the bog to suitable watercourses.	Positive	Drainage channels of sufficient capacity will ensure any overtopping water from the bog does not enter adjacent land. Drainage channels will also act as a hydraulic break in groundwater limiting the impact of bog measures to the groundwater in adjacent lands.
Turn off or reduce pumping	Existing pumps that aid discharge flow from the bog would be turned off or reduced to reduce the discharge and promote the rewetting of the bog.	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains located downstream. Raised groundwater levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Ground water levels in lands within this hydraulic gradient will potentially rise. The effect will be greatest immediately beside the bog. Unintended spill points may occur into adjacent land should water levels be allowed to rise.
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 are designated for wetland creation. Standing water will be allowed to occur resulting in increased water storage. Establishment of reeds and other	Positive and negative	Reduced runoff from the bog discharge points resulting in less flow in the external drains and river located downstream.

	rhizomes will form part of the wetland creation.	Raised groundwater levels to the bog surface will create a hydraulic gradient across the bog into the adjacent land. Land within this hydraulic gradient will potentially rise. The effect will be greatest immediately beside the bog.

3.2 Impact Assessment

Three potential impact sources were identified; groundwater rise, increased runoff from the bog and reduced drainage capacity into the bog. These impact sources have the potential to make the adjacent land wetter and drain less efficiently. An assessment was carried out to delineate the zone of influence resulting from these potential impact sources. Figure 3.2 presents the areas which are at potential risk.

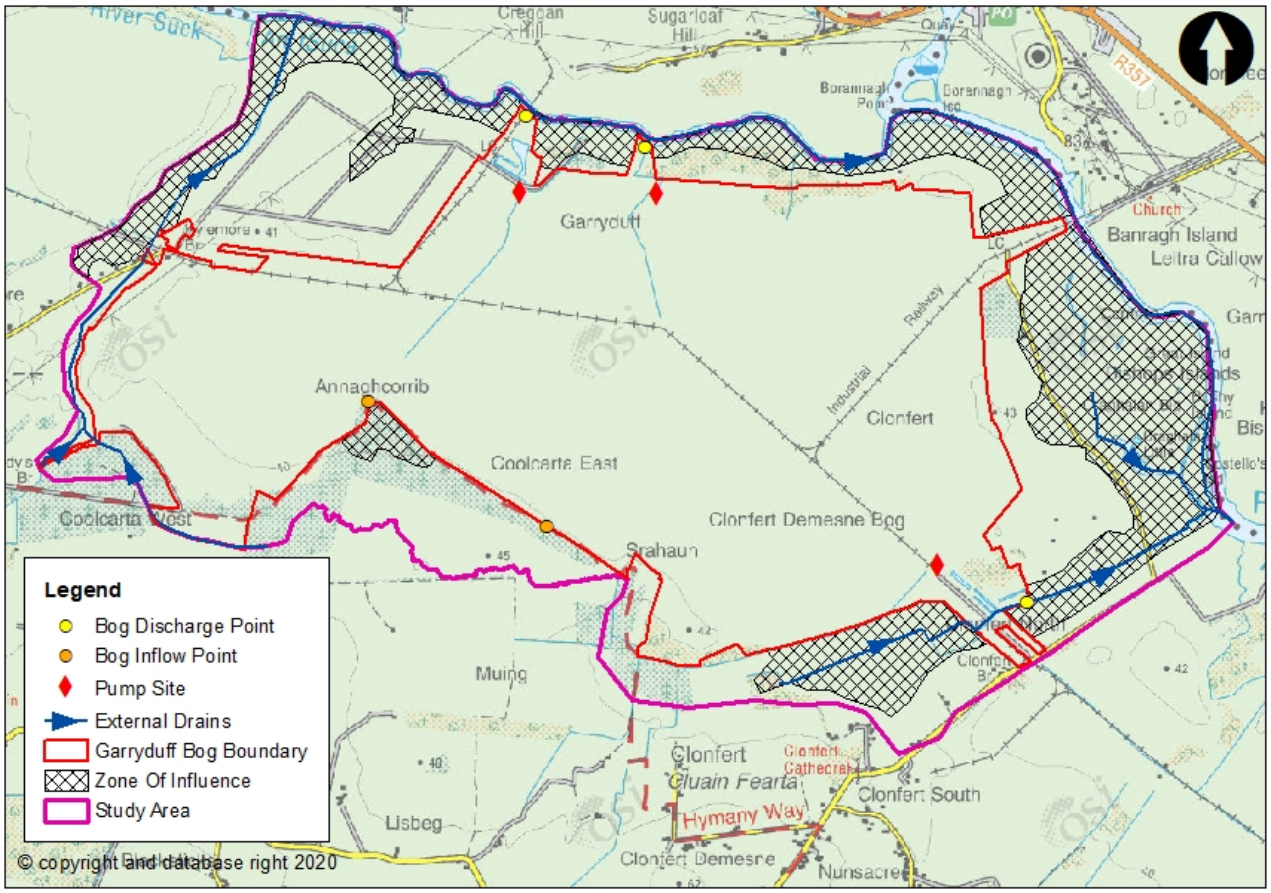

Figure 3.2 Garryduff Bog Rehabilitation Plan – Zone of Influence

3.2.1 Groundwater Impact

The impact of rehabilitation measures on groundwater 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 groundwater 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 is assumed that the maximum level which groundwater will reach outside areas zoned as wetland is the surface of the peat fields post-rehabilitation. This is because this ground is raised higher that the surrounding peat fields and drains under gravity. The topographical flow paths for surface water out of these areas will be retained. For areas zoned as wetland the maximum water level could potentially be up to 2m above surface level as water ponding is promoted through rehabilitation measures.

Groundwater rise in lands adjacent to the Garryduff Bog was assessed firstly by estimating the potential rise in groundwater within the bog. Water level rise in wetland areas is expected to be greater than ground level and will be determined by the higher surrounding bog and by the outlet control to the wetland area. As the groundwater rises in the bog a head water difference will be created between the bog and adjacent land forming a hydraulic gradient (see Figure 3.3a and 3.3b). Groundwater will flow across the hydraulic gradient. This flow will be dependent on the porosity of the ground it flows through and the head difference. This will determine the extent of the zone of influence and the area of potentially wetter ground. Where external drains are located in the zone of influence they will act as a hydraulic break or groundwater cut-off and reduce the zone of influence (see Figure 3.3c). This however is dependent on the drain's ability to convey water away. Drains that are inefficient with high water levels (independent from the bog rehabilitation measures) will also raise the groundwater and the adjacent lands to the bog would be wet (see Figure 3.3d). The avoidance of the drain full condition is dependent on maintenance of a positive gravity drainage function of the boundary drains through monitoring and maintenance.

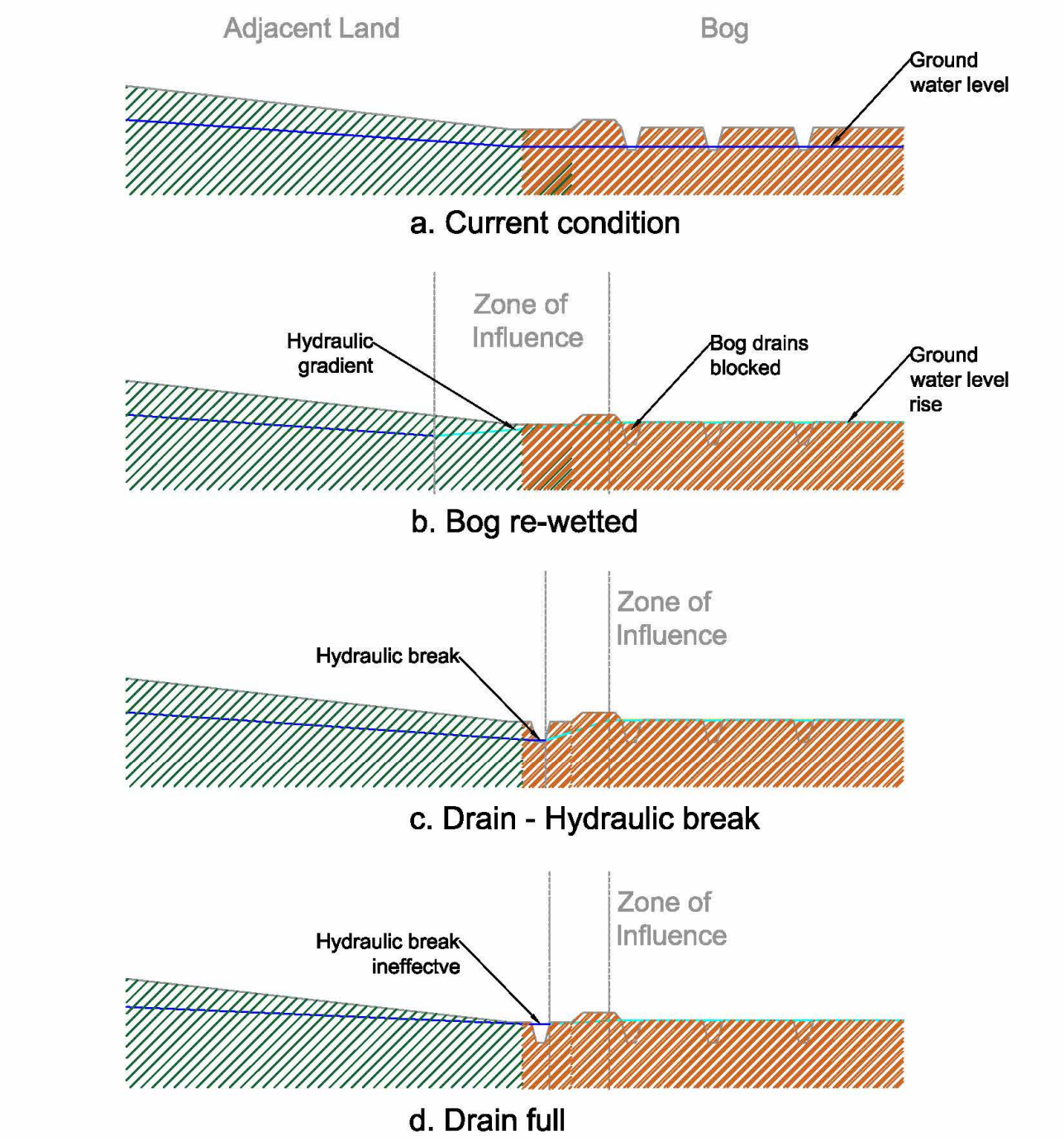

Figure 3.3 Conditions affecting groundwater

A complete survey of the boundary and external drains which provide the groundwater cut-off function to agricultural lands was not available for Garryduff Bog. 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 Garryduff 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.

There is also a risk that as the bog fills with water and wants to discharge, that unintended discharge locations would occur. A review of the bog boundary was carried out. No low points were identified that would be likely to become spill points from the production field bogs, however water levels will be regulated by suitable discharge control measures ensuring that no unintended spills occur. The north boundary of the bog discharges directly in the River Suck. As such there is little risk to adjacent lands should there be increased flows from the bog owing to elevated groundwater levels. However as previously set out this is based on the ability of the existing boundary drainage network, separating the bog from adjacent lands at a lower level, to provide a positive gravity drainage function in relation to groundwater entering the drain. 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 Insufficient Drainage

It is a significant concern for adjacent landowners that restoration and rehabilitation measures could lead to localised impacts in terms of reduced drainage leading to flooding of agricultural lands upstream of the bog.

There are two inflow locations to Garryduff Bog (Figure 3.2) which connect to drains which flow north and south west through the bog. An assessment was carried out of the drainage from these adjacent lands into and through the bog. The fall between the adjacent lands and the bog was estimated to be, on average, between 1m -1.5m. This fall will provide a positive drainage path from the adjacent land into the bog provided the bog inflow points are retained and there is no risk of backwater from the bog extending as far as the bog inflow points / invert levels.

3.2.3 Increased Runoff

Evidence from bogs that have previously been the subject of restoration measures demonstrates that the measures proposed at Garryduff, 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 following rehabilitation measures. Monitoring found that this occurred as runoff from the moorland was reduced due to increased storage in the peat.

The risk of increased runoff from Garryduff 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 Garryduff as the re-profiling of the bog will generally result in the same topographical flow paths, catchment watersheds and discharge locations as in the pre-rehabilitation state. However in the absence of a full pre and post rehabilitation runoff model and in line with a precautionary approach it is prudent that all drainage infrastructure from the bog is fit

for purpose and retained such that at a minimum capacity to convey high frequency flood events (Q_{med} or 2 year return period) is provided.

3.3 Potential Risk Areas

The assets that have been identified as being at potential risk from flooding or wetter conditions as described in Table 3.1 are shown in Figure 3.4.

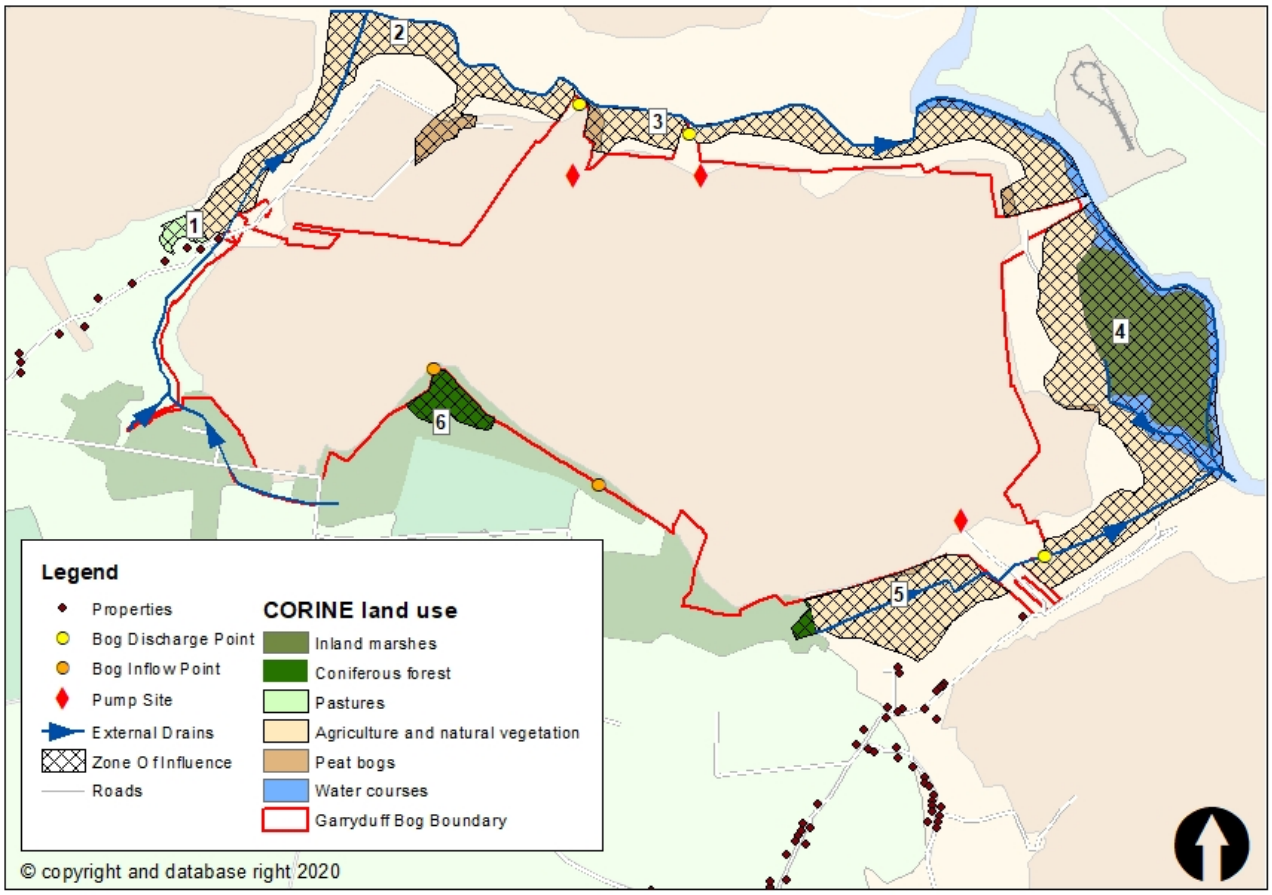

Figure 3.4 Garryduff Bog Rehabilitation Plan – Assets at Risk

The assets at risk are set out in Table 3.3 along with the vulnerability, based on the current land use, of the asset. It should be noted that the appraisal of the assets at risk is considering 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 with natural vegetation	High Vulnerability. Land would become less productive should it be made wetter.

2	Peat and agricultural land with natural vegetation	High vulnerability. Assumed turf cutting. Land would become less productive should it be made wetter.
3	Agricultural land with natural vegetation	High Vulnerability. Land would become less productive should it be made wetter.
4	Agricultural land with natural vegetation and inland marshes	High Vulnerability. Land adjacent to bog is agricultural land with natural vegetation and would become less productive should it be made wetter. Inland marshes could tolerate wetter conditions.
5	Agricultural land with natural vegetation and coniferous forest	High Vulnerability. Agricultural land would become less productive should it be made wetter. Commercial trees require good drainage. Should the ground become wetter the growth rate of the trees may be reduced.
6	Coniferous Forest	Moderate vulnerability. Commercial trees require good drainage. Should the ground become wetter the growth rate of the trees may be reduced.
7	Roads	Low vulnerability. Road level slightly higher than surrounding land. Risk of flooding is low.
8	Properties	Moderate Vulnerability. Although the impact of wet ground conditions or flooding to properties would be considered high, the location of these properties is mostly away from the bog at the limit of the zone of influence or the level of the property is at a higher elevation than the surrounding land. A number of the properties are agricultural sheds which would be more resilient to any potential flood risk.
9	River Shannon/Suck	Low Vulnerability. Water quality would reduce with increased sediment entering the River Suck. Existing silt ponds would continue to manage sediment. Vulnerability is therefore considered 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 Garryduff Drainage Management Plan is to facilitate the rehabilitation of bog through management of potential adverse impacts to adjacent land and waterbodies. SMART[3] 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 groundwater impacts between adjacent land and Garryduff bog during and after rehabilitation measures.
2. To maintain or reduce flows released from the bog at the discharge locations.
3. To reduce sediment entering the River Suck during and after rehabilitation, these measures are to ensure compliance with current discharge limits in IPC Licence.

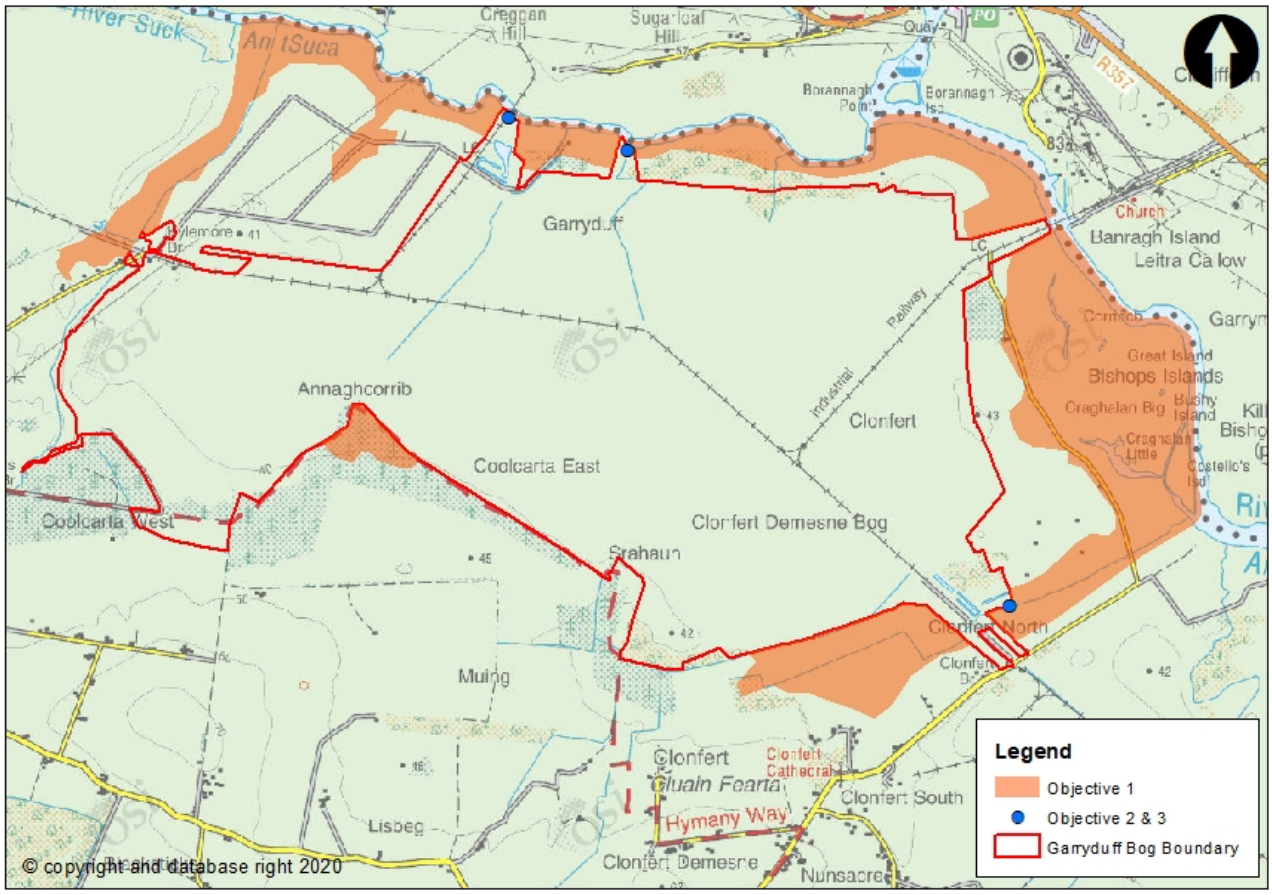

Figure 4.1 Garryduff Bog DMP Objectives

[3] 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 groundwater rise. Objectives 2 and 3 consider the control mechanisms to flow discharging from the bog.

An assessment was carried out to identify the key drainage features required to meet the objectives set. Figure 5.1 presents these features. For groundwater level rise to be managed between the bog and adjacent land existing drains acting as hydraulic break can be used. There are, however, only a few locations where suitable boundary drains currently exist. To ensure that the flow and sediment discharging from the bog is managed the discharge control points will need to be maintained.

Although outside the Bord na Mona 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 ensure that the bog will not contribute to an increased risk of sediment deposition arising from rehabilitation. Should this occur drainage from the bog could be impeded and adjacent land could become wetter.

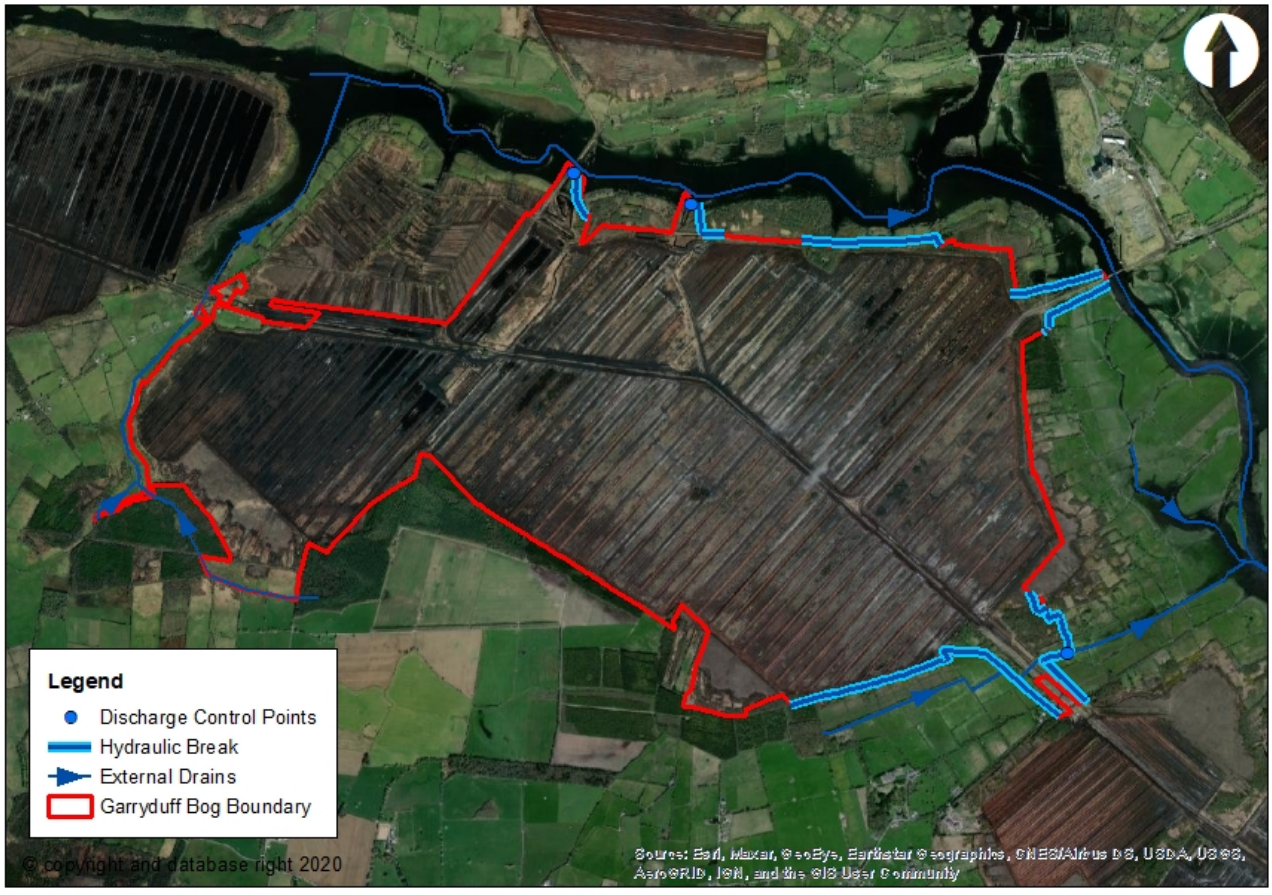

Figure 5.1 Key drainage features for Garryduff Bog

When identifying measures to provide the key drainage features a review was carried out of the drains. The review found that there is limited data available for boundary drains to the bog and external drains within the adjacent land. While data is available for internal drains this was found to be limited also. It was therefore required to produce a Drainage Management Plan that could offer a suite of measures whereby the most appropriate measures can be selected based on the level of robustness and on-site observations. The DMP 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 Garryduff Bog Drainage Management Plan.

5.1.1 Boundary drains

Boundary drains can provide hydraulic breaks between the bog and adjacent land, see Figure 3.3. In most areas of Garryduff Bog there are no suitable boundary drains to use as hydraulic breaks. Those that are suitable to provide hydraulic breaks 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.

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, 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 groundwater to current conditions and providing a groundwater 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 ground water on adjacent lands setting a maximum permissible water level may be required.

5.1.3 Internal drain retention

Drains within the bog that include adjacent land within their sub catchment may need to be designated as key drainage features and retained to ensure that the drainage to the adjacent land does not deteriorate. As the majority of Garryduff Bog rehabilitation plan is proposed wetland retention of internal drains will not be feasible and alternative measures will be required.

As the intention is to stop pumping on the site it would be required to link areas currently undergoing pumping to the existing drainage network. In the case of drains with pump systems it may be more beneficial to remove the pump and a new drainage channel cut, where falls can be achieved (relying on gravity to function). These additional drains would be required as part of the retention of the internal draining system.

5.1.4 Maintenance of silt ponds

Existing silt ponds are located upstream of the bog discharge points. They help regulate the flow and level of suspended peat leaving the bog into the external drains and rivers. Bord na Móna have a legal responsibility to maintain these silt ponds and ensure their proper functioning capacity under the existing IPC Licence (Ref. P0502-01).

5.1.5 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. Otherwise monitoring should continue until environmental stabilisation.

5.2 Drainage assessment

A review was carried out of the existing drainage networks falling within the key drainage features as shown in Figure 5.1. These drainage networks were reviewed to the confluence with streams in order to identify potential downstream control features.

The estimated flood flows were compared with the hydraulic capacity of each of the control features which are important to the effective performance of the drainage network.

Two methods have been considered for the derivation of the Index Flood flow (Q_{med}) as set out in Section 2.2. There is a high degree of uncertainty in the estimation of flood flows at the small catchment scale and therefore the largest of the two estimates has been chosen for each sub-catchment in line with a precautionary approach to uncertainty. Flood flows for Q_{med} (50% AEP) and Q_{100} (1% AEP) peak flows for each sub-catchment have been calculated. A generalised growth curve for peat catchments in the midlands has been used, whereby a growth factor of 2.3 has been used to scale up the Q_{med} peak flow to determine the Q_{100} event (100 year return period flood event).

The best projections on the effect of climate change have been applied to determine the Mid-Range Future Scenario (MRFS). This represents a 20% uplift over the present day flood flows.

Table 5.1 Peak Flows in Each Sub-Catchment

Sub Catchment	Q_{med} / 50% AEP	Q_{100} / 1% AEP	Q_{100} / 1% AEP MRFS
1	0.036	0.088	0.105
2	0.024	0.058	0.069
3	0.813	1.920	2.304

4	1.063	2.519	3.023
5	0.581	1.348	1.617

5.2.1 Assessment Points

Assessment Points have been assigned at key / critical points within the drainage network identified in Figure 5.1 as providing a key drainage management function. The location of the Assessment Points is provided in Figure 5.2.

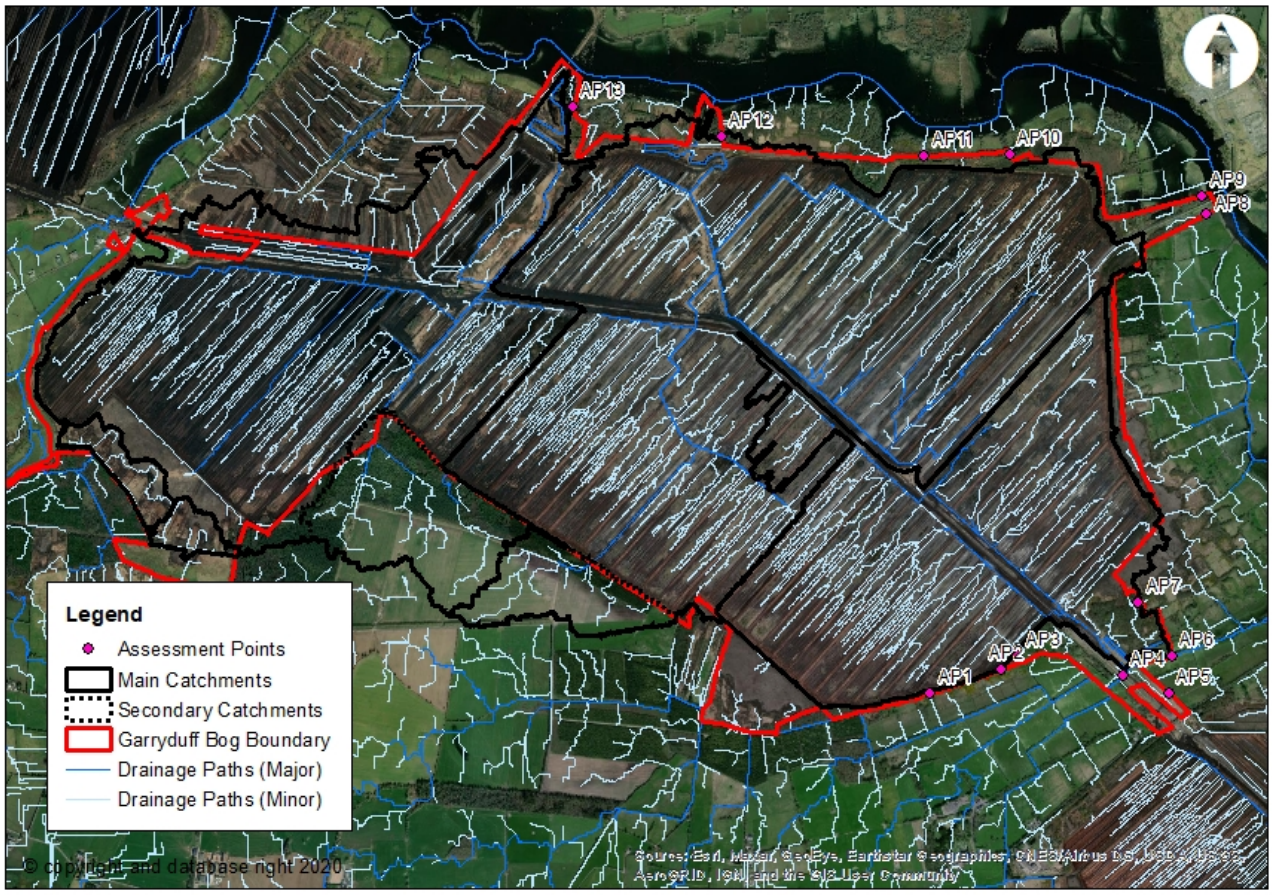

Figure 5.2 Assessment Points at Garryduff Bog

5.2.2 Hydraulic Analysis

The peak flows at each Assessment Point (AP) have been compared to the estimated hydraulic capacity of each of the features. A summary of the flood flows that may be generated at each AP along with their likely capacity to convey these flows is summarised below in Table 5.2. Note that capacity issues at an AP may have knock on impacts in terms of flooding for the APs upstream which is not captured in this point by point capacity check.

Table 5.2 AP Capacity

Ref.	Sub-catch.	Feature Type	Flood Flow Range (m^3/s)	Capacity & Recommendations
AP_1	5	Pipe	0.287 - 0.798	No data available. Alternative flow route available - no action necessary.
AP_2	5	Pipe	0.291 - 0.812	No data available**. Check pipe capacity when conditions allow.**
AP_3	5	Pipe	0.294 - 0.817	No data available. **Check pipe capacity when conditions allow.**
AP_4	5	Pipe	1.822 - 5.073	No data available. **Check pipe capacity when conditions allow.**
AP_5	5	Boundary drain	0.046 - 0.128	No data available. Drain does not border or convey flow from rehabilitation area.
AP_6	5	Boundary drain	2.456 - 6.837	No data available. **Check drain capacity when conditions allow.**
AP_7	5	Boundary drain	0.019 - 0.054	Capacity to convey flood flows but may not provide hydraulic break function.
AP_8	4	Boundary drain	0.100 - 0.283	Capacity to convey QMED.
AP_9	4	Boundary drain	0.032 - 0.090	No data available although drain sufficiently low so as not to represent potential constriction of flows away from bog.
AP_10	4	Boundary drain	0.016 - 0.045	No clear boundary drain at this location. Adjacent to Shannon floodplain.
AP_11	4	Boundary drain	0.021 - 0.060	No clear boundary drain at this location. Within Shannon floodplain.
AP_12	4	Boundary drain	0.018 - 0.051	No clear boundary drain at this location. Within Shannon floodplain.
AP_13	3	Boundary drain	0.011 - 0.030	No clear boundary drain at this location. Adjacent silt pond provides hydraulic break.

5.3 Identification of measures

The review of the boundary drains that could act as hydraulic breaks found few drains that would be suitable. As such the primary DMP measure identified was the control of water levels in the wetland areas. By ensuring water levels remain below set levels the risk of ground water flow across the bog into adjacent land and subsequent ground water rise would remain low.

DMP measures 19 to 24 refer to the wetland areas proposed as part of the rehabilitation plan. These wetland areas are located along the drainage path for adjacent lands that flow into the bog. As such it is important that adjacent lands can continue to drain through the bog and that the wetlands will not cause water to back up into the surrounding area. It is proposed for these DMPs that the maximum water level in the wetland areas is controlled to provide a freeboard of 500mm to the adjacent land draining into the bog. Where it is required to adjust outfalls as part of the rehabilitation measures the invert of the outfall that regulates the maximum water level will not be set higher than 34.0mOD for DMP measures 19, 20, 23 & 24 and 33.5mOD for DMP measures 21 & 22. These measures will keep the water levels sufficiently low in the wetlands so as not to

increase the risk of ground water rise in adjacent lands. It should be noted that during extreme flood conditions, that are beyond Bord na Móna's control, water levels in the wetland areas may rise above the invert of the outfalls as they regulate the discharge. If necessary, the proposed wetland areas can be adapted to function as silt control measures before the relevant part of the bog discharges through the various tributaries in the area to the Suck and Lower Shannon. A review of the internal drains would be required to ensure no drain bypass the wetlands.

DMP measure 7 refers to a boundary drain recommended for upgrade. This drain would act as a hydraulic break but would require deepening to the MPWL of DMP measure 23 (34mOD) in order to function efficiently. Other boundary drains have been identified for retention which will provide additional mitigation against ground water rise in adjacent lands.

DMP measures 10-18 identified areas of bog proposed for rewetting in the rehabilitation plan that are recommended for exclusion. This is due to there being no suitable boundary drain to function as a hydraulic break with the adjacent land and where the adjacent land is level or lower than the bog and as such would be vulnerable to ground water level rise.

DMP measures 8 & 9 refer to drains at bog inflow points. While there is little risk of adjacent land flooding due to this land being higher than the bog the drains at the inflow points should be retained to ensure free drainage.

DMP measure 26 refers to pumped discharge points which will be turned off as part of the rehabilitation plan. When this occurs, there will be a risk of unintended spill points occurring from the bog. The rehabilitation plan will likely require new discharge configurations at these locations. The function of these discharge points should control the silt and flow from the bog.

The remaining measures are of low intervention consisting of maintaining the existing features or monitoring lands and features.

Table 5.3 and Figure 5.3 details the level of intervention required.

Figure 5.3 DMP measures for Garryduff Bog

Table 5.3 Selection of DMP measures

Measures Item	Feature	Function required	Suite of measures Level of intervention			
			Low			High
1	Internal drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
2	Internal drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
3	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
4	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
5	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
6	Boundary drain	Hydraulic break	**Retain drain**	Upgrade drain	Maintain outside bog field	Create new drain
7	Boundary drain	Hydraulic break	Retain drain	**Upgrade drain**	Maintain outside bog field	Create new drain
8	Internal drain	Drainage of adjacent land	**Retain drain**	Upgrade drain	-	Create new drain
9	Internal drain	Drainage of adjacent land	**Retain drain**	Upgrade drain	-	Create new drain
10	Production field and drain	Hydraulic break	-	-	**Exclude from rehabilitation plan**	Create new drain
11	Production field and drain	Hydraulic break	-	-	**Exclude from rehabilitation plan**	Create new drain

Measures Item	Feature	Function required	Low	Suite of measures Level of intervention	High
12	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
13	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
14	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
15	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
16	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
17	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
18	Production field and drain	Hydraulic break	-	**Exclude from rehabilitation plan**	Create new drain
19	Wetland	Water level control	-	**Rehabilitation adaptation**	Exclude from rehabilitation plan -
20	Wetland	Water level control	-	**Rehabilitation adaptation**	Exclude from rehabilitation plan -
21	Wetland	Water level control	-	**Rehabilitation adaptation**	Exclude from rehabilitation plan -
22	Wetland	Water level control	-	**Rehabilitation adaptation**	Exclude from rehabilitation plan -
23	Wetland	Water level control	-	**Rehabilitation adaptation**	Exclude from rehabilitation plan -

Measures Item	Feature	Function required	Low	Suite of measures Level of intervention		High
24	Wetland	Water level control	-	**Rehabilitation adaptation**	Exclude from rehabilitation plan	-
25	Silt ponds	Silt and flow control	**Maintain pond**	Upgrade pond	-	-
26	Pump	Flow/silt control	Maintain current pumping regime	Upgrade drain	-	**Create new discharge point**

5.4 Interaction with monitoring plan

As part of the bog rehabilitation plan groundwater level monitors will be installed at Garryduff Bog. These monitors will record groundwater levels over the coming months. It will therefore be possible to ascertain if groundwater 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 groundwater levels are known to be rising within the bog, monitoring of the adjacent land (as described in Section 5.1.5) should take place on a more regular basis to ascertain if impacts to lands outside the bog are observed.

5.5 Residual Risk & Limitations

The level of flood risk to the bog and the surrounding lands has been shown to be high (Section 2.6). The impact of the proposed rehabilitation measures will generally be to reduce runoff from the bog but this will lead to increased groundwater levels and surface water flooding in the bog itself. There are unknowns in relation to the post-rehabilitation water levels which will be realised, however the Drainage Management Plan seeks to identify the measures that will provide a mitigation of impacts to 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 however a suite of measures in any given location has been provided. This will allow a reactive approach to be taken if required. Should a measure not be operating efficiently a higher intervention measure can be implemented. This will allow Bord na Móna to identify the most appropriate measure while proceeding with drainage function uncertainties.

5.6 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[4]. 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 Garryduff Bog are the cause of increased flood risk.

[4] 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 BRP measures in mitigating these climate change impacts.

6 SUMMARY OF DRAINAGE MANAGEMENT PLAN

The Drainage Management Plan for Garryduff consists of a series of measures to be implemented at different stages of the rehabilitation measures. The primary measure sets a maximum permissible water level for each wetland area. This measure is to control the potential ground water level rise in adjacent lands.

Drains within the bog and along its boundary were identified as being key drainage paths or 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 5.3 and deemed appropriate 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.

Other measures range from low intervention to high and consist of monitoring, retention of existing features, upgrading features and updating the rehabilitation plan. 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 lands was included in the plan. The monitoring will observe adjacent bog and woodland for adverse impacts from the bog rehabilitation. Should these impacts be confirmed, higher intervention measures can 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 internal and boundary drains (see section 5.1.1)	-	-
Upgrade of boundary drain (see section 5.1.1)	-	-
-	Wetland water level control (see section 5.1.2)	Wetland water level control (see section 5.1.2)
-	Field bog exclusion from rehabilitation plan (see section 5.1.2)	Field bog exclusion from rehabilitation plan (see section 5.1.2)

-	Upgrade and create new discharge points at pump locations (see section 5.1.3)	-
Monitoring external drains	IF REQUIRED – Consideration of need for higher intervention measures	-
Maintenance of silt ponds (see section 5.1.4)	Maintenance of silt ponds (see section 5.1.4)	Maintenance of silt ponds (see section 5.1.4)
Monitoring of adjacent land (see section 5.1.5)	Monitoring of adjacent land (see section 5.1.5)	Monitoring of adjacent vulnerability land (see section 5.1.5)
-	-	IF REQUIRED – boundary drain upgrades (see section 5.1.1)
-	-	Retention of key drains and pipes