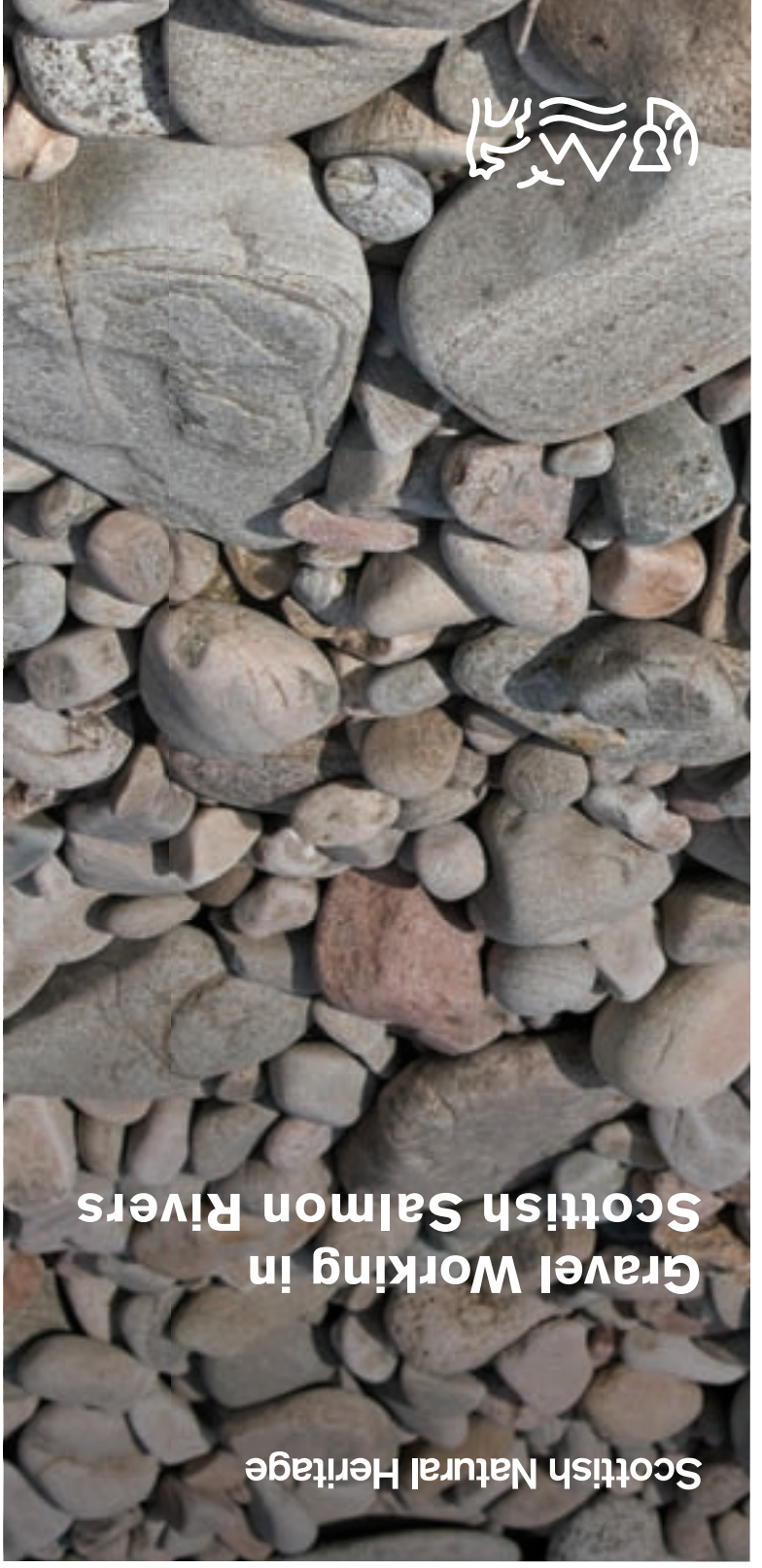

Why is this guide important to me?

This leaflet provides guidance for anyone considering gravel extraction or management in salmon rivers in Scotland. It is for gravel works associated with flood alleviation, land drainage, aggregate working, fisheries improvements, river protection and protection of bridges and culverts. It supplements guidance from SEPA, the responsible authority for licensing gravel extraction under the Water Environment (Controlled Activities) (Scotland) Regulations 2005.

What is gravel?

- Gravel is a highly mobile material
- Larger than sand in size (2mm) but smaller than boulders (256mm) which erodes in some areas and deposits in others

Why is gravel important?

Gravel movement allows the river to adjust its size and shape so during floods increased water levels can be accommodated, and erosion can be reduced.

Gravel movement creates a varied river bed with deep pools, shallows and exposed accumulations of gravel. These in turn create various types of flow and provide habitats for fish and other species under drought, normal and flood conditions.

Gravel provides habitats, on and within which many creatures complete one or more stages of their lifecycle, and is used by them to escape hostile floodwaters.

Exposed accumulations of gravel are important as havens for a range of plants and animals.

Scottish salmon rivers are home to several species of European importance, all of which directly depend on gravel for survival.

Appropriate gravel management is ESSENTIAL!

The gravels in river beds are constantly moving and the bed changing shape. This is natural and ensures the river can protect itself and the surrounding land from flood damage. This means that the position of the river or degree of gravel accumulation will constantly be changing on any parcel of land.

As gravel moves on a 'conveyor belt system' from headwaters to the river mouth, any interference with this system (extraction or manipulation) may impair the ability of the river to protect itself and the surrounding land from flood damage further downstream: gravel work intended to ease flooding on your land may exacerbate flood damage on land further downstream.

Extraction and manipulation of gravel in the river will damage the bed armour which will lead to loss of gravel and channel destabilisation. Flood damage will increase.

Due to natural and man-made sediment traps on many rivers, gravel replenishment will decline over time (hundreds of years). Extraction operations will exacerbate the rate and hasten the decline in gravel volume. Less gravel reduces a rivers natural protection and may lead to more erosion.

Activity	Avoid	Recommendations
Land drainage	• Removing gravel to increase flow of water and deepen river. All this might do is cause erosion and flooding problems downstream. • Skimming off the top layer of gravel to increase flows, this is the "armour layer" and could destabilise large gravel beds in medium - high flows	• Alternatives such as channel restoration should be considered. SNH and SEPA must be consulted. • Remove small amounts of gravel accumulation which have formed around outfalls from field drains • Prevent sedimentation of gravels downstream of work. • Carry out any gravel work during period of least sensitivity: June to October
Aggregate extraction	• Taking gravel from gravel beds above low flows as these can be re-mobilised in flood events. • Taking gravel from plant rich stable beds just outwith the river channel. • Carrying out in-river gravel extraction. • Taking gravel from bars. • Skimming off the top layer of gravel, this is the "armour layer" and could destabilise large gravel beds in medium - high flows	• Take gravel from dry borrow pits, above the water table, elsewhere on land away from river. • Ensure pits are located outside the riparian zone. • Do not process or wash gravel where waste water can contaminate waterways. • Implement a fish rescue plan if fish become trapped in pits during floods. • Locate pit in an area where there is minimal possibility of future stream connection. Specialist studies can help predict this.
Fisheries management	• Cleaning out pools, or using river gravels for croy repairs or carrying out channel modification. Feedback from managers on the Tay is that there is little need for gravel removal for fisheries and often it is not feasible due to the size and depth of the river.	• Undertake planned habitat restoration work which directly improves salmonid habitat. SNH, SEPA and the local District Salmon Fishery Board should be consulted. • Carry out work during the period of least sensitivity: June to October

River Processes

Erosion

Swift flows in headwaters cause erosion of stream banks and beds. The material produced from this erosion is gravel - a legacy of the last glaciation. Unregulated, natural tributaries are the main source, but re-working of gravel islands and bank erosion on the main river stem can also provide further gravel input.

Movement

Rivers move their historical store of gravel from headwaters to the river mouth. At any point on a river material lost downstream is replenished by material added in the upper reaches. Only during flood events are significant levels of gravel transported and gravel islands re-worked. This creates an ever changing river bed with deep pools and shallows and areas of slow and fast moving water. Large shoals and accumulations of gravel above the normal water level are natural features of rivers.

Armouring

The surface layer of gravel bed rivers is often "armoured" by a layer of coarser particles providing a "protective blanket" to an assortment of finer gravel beneath. The armour prevents the fine gravel from being lifted and transported under all but flood flow conditions. The armoured layer is important to maintain the gravel resource and partially stabilize the channel.

Deposition and reworking

Gravel material is deposited in areas of slower flows. On some rivers this can lead to large accumulations, creating gravel bars and islands. Some of these islands can be in various stages of vegetation colonisation, creating unique habitats. Gravel bars and islands create a valuable multi-channelled river stem.

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Scottish Natural Heritage
All of nature for all of Scotland

Floodwaters move and deposit gravel to create a channel that is in 'equilibrium' with the river flow.
A natural river system requires less management.

"The floods of December 2006 caused new pools to form on the River Lyon whilst others disappeared. Even pools which filled up with gravel were cleared out again in subsequent floods"

Dr David Summers,
Tay District Salmon Fishery Board

Impacts on the physical environment

Almost any amount of gravel working can have long-term impacts over large distances downstream. Ill-conceived gravel working can compound problems and lead to conditions where more and more management is necessary. The main, and most serious impacts are from loss of gravel from the system, loss of the river bed 'armour layer', and the formation of single thread channels.

Loss of gravel from the system

Gravel extraction will interrupt the 'conveyor belt' movement of sediment downstream. If the amount taken from a reach equals or exceeds the natural input, the conveyor will be broken at that point and the volume of gravel in downstream reaches will diminish. Starvation disrupts the 'conveyor belt' and reduces the ability of the river to redistribute gravel to accommodate floodwaters. Flood impact will inevitably increase. Impacts worsen over the long-term with the effects being felt further and further downstream. Dry removal from exposed bars has the same effect.

Loss of the Armour Layer

Skimming off the top layer of gravel, the "armour layer" is particularly damaging. This layer, made up of larger stones over finer material protects the fines from the erosive action of the river in low to medium flows. Removing the armour layer allows the river into easily mobilised material and can in medium to high flows destabilise large gravel beds

Creation of single thread channels

When extraction reduces the amount of sediment available to be transported downstream, over time single-thread channels are formed. During floods the capacity of the river to accommodate excess water is reduced and floodwaters will spread further over the floodplain. Flood water flowing through a single channel is faster and more erosive and thus may cause more damage to riverbanks and surrounding land.

Likely impacts on river ecology

Salmon and Lampreys

Clean oxygen-rich gravel is required during spawning as this is where the salmon excavates a 'redd' and deposits its eggs, and where the young hatchlings remain for the early stages in their life. Lampreys are primitive, jawless fish with a sucker-like mouth.

Removal of gravel itself reduces the availability for salmon redds or spawning areas of lamprey. Resultant increased erosion causes scour of riffles used by juvenile fish and reduced areas of pools where adult salmon sit. If fine sediment is released into the watercourses during gravel management, this can smother the gills of salmon or lamprey or impede their passage upstream. It can also smother the gravels used for spawning salmon and lamprey or the areas used by juvenile fish, making them unsuitable.

Element of instream sediment removal	Physical effect	Consequence
Removal of gravel from a location or from a limited reach	Propagates channel both upstream and downstream from excavation site. Scour of upstream riffles Reduced pool areas	Net loss of gravel from system. Rivers' ability to accommodate floodwater is reduced. Flood damage increases. Channel degradation increases erosion and flood damage increases. Habitat degradation reduces ability of gravel-dependant species to survive
Removal of gravel from exposed bars	Loss of gravel from downstream bars. Less lateral variation in depth and reduced prominence of the pool-riffle sequence. Channel degradation.	Net loss of gravel from system. Rivers' ability to accommodate floodwater is reduced. Flood damage increases. Channel degradation increases erosion and flood damage increases. Habitat degradation reduces ability of gravel-dependant species to survive.
Removal of gravel in excess of the input or reduced downstream gravel supply	Complex channels regress to single thread channels. Armouring of channel bed. Erosion of banks and bars	Increase in current speed increases erosion and causes more flood damage.
Removal of vegetation and woody debris from bar and bank	Reduction in shade. Decreased channel complexity. Decrease in food inputs	Reduction in cover for river species. Reduction in number and depth of pools and salmon spawning areas. Limit channel stability. Decrease stream productivity

Activity	Avoid	Recommendations
Flood alleviation	• Undertaking small-scale flood alleviation works unless in case of emergency. There is little objective or scientific evidence that the perceived benefits are real or more than temporary. Flood alleviation works could have serious knock-on effects downstream.	• Before implementing a major flood alleviation scheme a sediment transport model should be undertaken and an options appraisal of alternatives and investigations of causes. SEPA should be contacted for advice on how to do this. • Ensure channel can maintain sediment sorting processes so pool and riffle sequences remain or can be restored. • Ensure there is negligible increase in bed scour to preserve spawning beds. • Avoid bar removal to maintain channel complexity if possible. • Prevent sedimentation of gravels downstream of work. • Carry out any flood alleviation work during period of least ecological sensitivity: June to October • Use excavated gravel to replenish the river system downstream, don't remove from site. • Avoid riparian areas and stable vegetated bars if possible. • Leave or replace woody debris if possible.
Protection of bridges & culverts	• Undertaking small-scale flood alleviation works unless as an emergency. There is little objective or scientific evidence that the perceived benefits are real or more than temporary. Flood alleviation works could have serious knock-on effects downstream.	• Justified on small scale to protect integrity of structures. Recurring problems suggest the need for specialist surveys. • Prevent sedimentation of gravels downstream of work. • Carry out any protection work during period of least sensitivity: June to October • Use excavated gravel to replenish the river system downstream, don't remove from site. • Avoid riparian areas. • Leave or replace woody debris if possible.

Freshwater pearl mussel

Freshwater pearl mussels live buried or partially-buried in the sand and gravel on river beds. As a result of pearl fishing and pollution they are now very rare. The Scottish populations represent at least half the known worldwide population. They can be found where salmon have had historical access - the young larva depend on attaching themselves to the gills of salmon or trout for survival. Juvenile pearl mussels are vulnerable to any reduction in water quality as they live buried within the river substrate and are badly affected by sediment loading and untreated gravel washings entering the river.

Riparian Habitats

Along many gravel banks on shallow gravel and sandy soils, diverse calcareous and neutral grasslands have often formed. Throughout Britain these herb rich grasslands have been lost to agricultural improvement and riverbanks form a remaining stronghold. These often narrow strips of grassland along river banks have formed on free draining skeletal soils over gravel deposits. They benefit from flooding to bring nutrients and remove rank vegetation. Many have been lost to erosion due to inappropriate flood protection and gravel removal from these vegetated stable beds for on-farm repairs and for flood bank repair has destroyed much of this scarce type of habitat.

Residual alluvial forests depend on the ever changing face of braided rivers. They are found on floodplains and islands in river channels and on low-lying wetlands alongside channels. They are part of a dynamic system of habitats often consisting a series of extensive shingle areas in various stages of colonisation from bare shingle to mixed woodland and includes historic river channels.