Controlled Activities Regulations (CAR) Flood Risk Standing Advice for Engineering, Discharge and Impoundment Activities.

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Activities such as impoundments and engineering within the vicinity of a watercourse have the potential to impact on the water environment and are therefore authorised under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR). This includes activities to mitigate flood risk**.** While SEPA provides statutory advice about flooding to planning authorities, flood risk is not a regulatory function within the licensing of activities under the CAR. SEPA will not seek to control or regulate flood risk through CAR; our regulatory duties only extend to the protection of the water environment.

This guidance provides key information which should be followed when planning discharge, engineering, or impoundment activities in or within the vicinity of a watercourse, by providing an overview of the flood risk issues associated with different activities. **It is the responsibility of the individual to consider the flood risk associated with an activity and if necessary commission a Flood Risk Assessment to fully understand the impact the activity will have. As many engineering and impoundment activities also require planning permission we would recommend early consultation is made with your Local Authority**.[1]

More information on the licence determination process that SEPA follows can be found in the regulatory methods for impoundments (WAT-RM-01), engineering (WAT-RM-02) and discharges at http://www.sepa.org.uk/water/water_regulation/guidance.aspx.

General flood advice for a range of activities is provided below and while not exhaustive, should provide a preliminary tool to identify flood risk matters and subsequent guidance documents to refer to.

General guidance:
CIRIA C624: Development and Flood Risk – Guidance for the Construction Industry.
Planning Advice Note 69
Scottish Planning Policy
CAR Practical Guide
Technical Flood Risk Guidance

Activities:

Culverts and bridges
Diversions and realignments
Embankments and walls
Sediment management
Grey bank engineering
Discharge alterations
In-stream structures, impoundments and ponds
Natural flood management

[1] For any CAR activity applications which breach environmental standards, any flood risk considerations will be taken into account where the proposal is subject to a Derogation Test (WAT-RM-34) when assessing the balance between negative and positive impacts

Culverts and bridges

The design of individual bridges and culverts is important to reduce the potential flood risk associated with these structures. It is important to consider the size, slope, and route when installing a culvert or bridge as:

- Under-sizing a bridge or culvert can restrict river flow and increase flood levels locally on the upstream side. Water backing up behind a structure can also bypass the channel and travel down alternative flow paths e.g. roads, creating flood risk to other areas. SEPA would recommend the 200-year design flow standard to be adhered to.
- Increasing the size of a replacement bridge or culvert may only serve to increase the risk of flooding downstream as more flow is passed downstream. Unless there is a good justification, SEPA would recommend replacing a bridge or culvert with a similar size and shape.
- The chance of failure increases if the bridge or culvert is poorly designed.
- The cost to the applicant could be significant should the structure have to be replaced due to a failure or if the structure passed on the flood risk to other property or infrastructure.

There may be some instances when the design standard adherence may become less important, and a more bespoke design standard is used. For example, in very remote locations, an increase in the bridge or culvert size (beyond its original capacity) could be acceptable, as a betterment is being achieved in terms of protecting the road from flooding. There may also be instances where a much smaller bridge or culvert may be beneficial to throttle and attenuate flows, e.g. on the upstream side of a road, if local topography allowed. In such cases, no single design standard of conveyance capacity may apply and, as said, a bespoke design may be required.

Culvert design and flood risk best practice

- The structure should be able to convey peak flood flow giving due consideration to an amount lost through burying the invert level.
- A suitable freeboard should be included to allow for extra capacity during extreme floods and uncertainties in the design flows.
- Scottish Planning Policy refers to the avoidance of culverting whenever possible. If culverts are unavoidable, they should be designed to maintain or improve existing flow conditions.
- Minimise sharp bends, and changes to slope and culvert sizing, that will reduce capacity, catch debris, and encourage deposition.
- A safe overland flow path should the culvert capacity be exceeded that directs water away from vulnerable property and infrastructure and back into the burn.
- Deem whether a trash screen is required and suitably designed. A maintenance regime will reduce the likelihood of blockage.
- Depending on the culvert length, consideration of man-holes to enable inspection and maintenance of the structure.
- There should be no hydraulic drop at the culvert inlet or outlet as this encourages sediment deposition and increase the risk of blockage to the culvert and flood water bypassing the structure.
- The culvert base shall be below the natural bed level, and the natural bed level maintained. Placing a culvert on top of the natural bed level could result in the structure being undermined and flood water bypassing the structure.
- The approach channel to the culvert (and outlet) should be suitably straight to reduce

the risk of blockage and sediment deposition.
- The risk of blockage is generally higher for multiple culverts as they tend to be smaller in size.

Bridge design and flood risk best practice

- The structure should be designed to convey peak flood flow.
- A suitable freeboard should be included to allow for extra capacity during extreme floods, uncertainties in the design flows and potential blockage from debris.
- The design of any in-stream structures e.g. piers; should not encourage the deposition of sediment or debris. A clear span bridge is recommended where possible.
- The design of any in-stream structures should not cause erosion to the bed or banks or direct flows towards the banks thus causing erosion as the additional sediment can be deposited downstream thus increasing flood risk.
- The design of the structure should not result in any narrowing of the channel width.
- The provision on a safe overland flow path, where possible, should the bridge capacity be exceeded.
- Deem whether a trash screen is required and suitably designed. A maintenance regime will reduce the likelihood of blockage.

Guidance documents

- SEPA Position Statement PS-06-02
- SEPA Good Practice Guide River Crossing WAT-SG-25 (pdf, 11mb)
- SEPA standing advice – Appendix 2, Section 8 (LUPS-GU8)
- SNH/SEPA joint wind farm guidance (external)
- CIRIA C624: Development and Flood Risk – Guidance for the Construction Industry. (external)
- CIRIA C689: Culvert Design and Operation Guide (external)
- CIRIA C551: Manual on Scour at Bridges and Other Hydraulic Structures (external)
- River Crossings and Migratory Fish: Design Guidance (external)
- Environment Agency Fluvial Design Guide - Chapter 11 (external)

Diversions and realignments

The flood risk posed by a poorly designed channel diversion or realignment can have a range of consequences and are dependent on the channel design and local topography. When proposing a change to the channel shape and length important considerations include:

- Lengthening a channel compared to the existing dimensions can decrease velocities (i.e. the speed the water moves down the river) as slope is reduced. As slope affects the speed of the water, local flooding may be more likely as velocity decreases.
- Shortening a channel, compared to the existing dimensions, can increase velocities as slope is increased and pass more flow downstream. This can have far reaching consequences especially if there are restrictions in the channel downstream, e.g. bridge or culvert, where water can back up behind the structure. It also encourages erosion of the bed and banks of the river and any in-stream structures, e.g. culverts or bridge piers.
- Narrowing a channel compared to the existing dimensions can increase velocities and pass more flow downstream. However, it can also reduce the volume of water able to fit in the channel as surface area is reduced and can result in increased flooding frequency locally. Increases in velocity can cause erosion, undermining banks and structures, and increasing sediment movement downstream which then poses blockage risk to downstream structures.
- Widening a channel compared to the existing dimensions can decrease velocities as surface area is increased. This can result in increased frequency of overtopping the channel locally as water is slower to move through the reach. It also encourages the deposition of sediment as the river loses its power and deposits what it has been carrying. This can result in the increase in flood risk in the long-term. Natural rivers tend to revert back to their optimum width over time.

Essentially, any changes in velocity can affect the transport of sediment which can undermine bridges, infrastructure, and property, or direct flow towards or away from vulnerable areas.

For diversions that result in water being routed into a different catchment see the advice provided in Discharge Alterations section.

Diversion and realignment flood risk best practice

- Minimise sharp bends and changes to slope which will affect velocity
- To minimise detrimental changes to the channel keep the proposed channel dimensions/ characteristics similar to existing channel dimensions, i.e. mimic existing channel plan form.
- The proposed channel should not be located closer to infrastructure or property compared to the existing channel as it can increase the risk of flooding to existing infrastructure or property.
- The channel should follow the natural topography of the land to ensure floodwater is returned to the watercourse thus limiting flooding elsewhere.
- Regular monitoring of the post engineering work should be undertaken.

Guidance documents
• The River Restoration Centre • Guidebook of Applied Fluvial Geomorphology R&D Technical Report FD1914 • WAT-SG-29: SEPA Temporary Construction Methods • River Diversions: A Design Guide. Fisher, K. & Ramsbottom, D. (2001). Thomas Telford Publishing

Embankments and walls

The construction or removal of embankments or walls can have significant impacts, locally and downstream, and is highly dependent upon how water moves through the river reach in question. Embankments or walls can increase flood levels during more frequent events as river flow is contained within the channel rather than spreading across the floodplain. However, during more extreme events, water can overtop the structure and be stored offline. Depending on the location and length of the wall or embankment this can have a positive impact of reducing the downstream flood peak before water is slowly released back into the channel. We accept that in some cases a benefit can be realised by the construction of a wall or embankment. However, overtopping can flood properties and infrastructure located behind it. Also, there are risks associated with failure or breach whereby flood water flows quickly through the gap causing rapid inundation.

We would highlight that embankments and walls not constructed through the appropriate flood management legislation (e.g. via permitted development rights) are not deemed a formal flood protection measure. Therefore, proposals to develop on floodplain behind such structures will not be supported and the embankment or wall may only serve to increase flood risk locally and downstream.

Embankments and walls constructed on the floodplain may require compensatory storage. More advice can be found on the Land-raising and Compensatory Storage section.

The removal of embankments to engage the watercourse with its floodplain should only be undertaken if an assessment has shown that there will be no increase in flood risk elsewhere. Studies within Scotland have shown that rural embankments can hold water back during large flood events before slowly releasing the water back into the river and have provided some positive benefit to downstream communities.

Embankments and flood risk best practice

- Local flood hydraulics need to be examined in detail to understand impacts fully from any embankment construction or removal.
- There should be no increase in flood risk elsewhere either by removing an area of floodplain or by directing water along different flow paths.
- The construction of an embankment should be set-back from the edge of the river to allow for some floodplain storage and reduce the risk of the banks being undermined by erosion.
- Embankments should be designed to protect to the appropriate standard of protection including freeboard and a climate change allowance. This should also include an allowance for settlement due to consolidation of the foundation and degradation of the crest from livestock or people.
- Built with an awareness of potential breach or failure implications.
- The integrity of the structure should be able to withstand flood events. Consultation with a geotechnical engineer is recommended.
- Awareness that embankments are susceptible to erosion, burrowing animals, and settlement and may require additional works.
- Do not erect fences on embankments as the posts can act as levers when submerged and increase the risk of embankment failure.
- Secondary defences may be required, e.g. a pump, to reduce the impact from any seepage under or through the structure and to reduce surface water backing up behind the embankment.

Walls and flood risk best practice

- Local flood hydraulics need to be examined in detail to understand impacts fully from any wall construction or removal.
- There should be no increase in flood risk elsewhere either by removing an area of floodplain or by directing water along different flow paths.
- The construction of a wall should be set-back from the edge of the river to allow for some floodplain storage and reduce the risk of the wall being undermined by erosion.
- Walls should be designed to protect to the appropriate standard of protection including freeboard and a climate change allowance.
- Built with an awareness of potential breach or failure implications.
- The integrity of the structure should be able to withstand flood events as the side-ways pressure during a flood event can cause sliding or rotation of the defence. Consultation with a geotechnical engineer is recommended.
- Secondary defences may be required, e.g. a pump, to reduce the impact from any seepage under or through the structure and to reduce surface water backing up behind the wall.

Guidance documents

- Environment Agency Fluvial Design Guide - Chapter 9
- SEPA Land-Use Vulnerability Guidance, Table 2 (LUPS-GU24)
- Planning Advice Note 69 (paragraph 14)

Land-raising and compensatory storage

Land-raising permanently removes an area of land above and out with the floodplain, reduces the volume of floodplain, and impacts on the conveyance of flows across the floodplain. This ultimately increases flood levels elsewhere. As it is important to safeguard the floodplain, works to elevate the level of a site should not lead to a loss of flood water storage and conveyance capacity.

In line with Scottish Planning Policy, any proposed land-raising should have compensatory storage provision up to the 200 year design level. In order to replicate the existing situation for a particular flood event, an equal volume of floodplain should be created. This ensures that flood water is not displaced elsewhere. We would stress that there should be no lowering of an area of existing floodplain as the void may already be full of water before the design flood level and therefore offer no storage. We also stress that we are generally not supportive of land-raising on Greenfield land as it is not aligned with sustainable flood risk management.

It should be appreciated that in order to undertake such works, the applicant will have to own sufficient land that is close to and higher in elevation than the area of floodplain to be raised. Compensatory storage areas are required to be safeguarded indefinitely for that use.

Land-raising and compensatory storage flood risk best practice

- Land-raising should be set-back from the banks of the watercourse to reduce the risk of failure from erosion.
- There should be a neutral or better impact on flood risk elsewhere.
- Compensatory storage should be close to the area of floodplain lost.
- Compensatory storage should be hydraulically and hydrologically similar to the location of the development.

Guidance documents

- Technical Flood Risk Guidance for Stakeholders
- CIRIA C624: Development and Flood Risk – Guidance for the Construction Industry

Sediment management

Sediment management covers a wide range of activities from small scale removal of dry sediments to large scale dredging of a channel reach. Removing sediment can reduce water levels in some instances however it should be noted that the river bed level may not be the dominant factor that controls water levels in a particular reach. Other factors include channel slope, channel roughness, engineering structures (e.g. weirs, bridges, and culverts), backwater effects from the tide, or the downstream main river or tributary may be more dominant factors in determining the level that a certain flow reaches in a channel reach.

The effect of dredging or removing islands in rivers can have less of an impact on flood levels than one may realise. Dredging is only a temporary measure to address a flood risk issue as the material that is removed is often replaced in a short period of time e.g. during the next high flow. Dredging can be expensive and needs consideration of the disposal of the material removed from the channel. Altering the configuration of the channel can destabilise the channel and promote erosion and deposition, not only within the engineered reach but also upstream and downstream. Erosion of embankments which provide protection to existing property and infrastructure can encourage flood water to spill out more often and flood the area more frequently. Eroded embankments are also more likely to fail.

Sediment management and flood risk best practice

- The works must not destabilise the river bed and banks as the additional sediment can increase flood risk elsewhere.
- An assessment of the potential increase in flood risk downstream may be required.
- Sediment removed is likely to accumulate from upstream in subsequent years and is only a temporary measure, and is therefore not normally a sustainable method of flood prevention.

Guidance documents

- Floods, dredging and river changes
- WAT-SG-26: Good Practice Guide - Sediment management
- Dredging: A Land Managers Guide

Grey bank engineering

Bank erosion is a natural process which promotes healthy and sustainable ecological habitats. However, it can also be caused or exacerbated by land management practices e.g. livestock management, vegetation management, and river engineering. Grey bank (or hard) engineering includes the use of rip-rap over the full height of the bank, gabion baskets, concrete, stone or brick work, sheet piling, wood piling, and non-biodegradable geotextiles. It is different from green bank (or soft) engineering which includes restricted materials along the bank toe.

If the grey-bank engineering is built too high i.e. above the adjacent bank, or too wide i.e. narrowing the pre-erosion channel, it can increase the risk of flooding by decreasing the channel capacity and increasing the velocity. This may have a knock-on effect on bank and bed stability elsewhere. It can also direct river flow towards other parts of the channel e.g. the opposite bank, and result in an increase in flood risk to areas previously regarded as relatively safe.

Where there is a risk to infrastructure, human health and safety, or the built environment, further erosion should be prevented where possible. It is worth highlighting that grey-bank engineering is likely a short-term solution and it is beneficial to identify the cause of the erosion and identify measures to reduce further erosion to reduce the long-term environmental and financial costs.

Grey bank engineering and flood risk best practice

- The activity should be proportionate to the scale and significance of the erosion.
- Height of bank works should be no greater than the existing bank.
- The engineered bank should not narrow the channel further than the pre-erosion width.

Guidance documents

- WAT-SG-23: Good practice guide – Bank protection
- Environment Agency Fluvial Design Guide - Chapter 8

Discharge alterations

Artificial increases in flow to a river can come from a variety of sources and can be long-term or temporary. Transferring water from one catchment to another effectively adds foreign water into the system. While it may reduce flood risk to one catchment, it increases the flood risk to the catchment receiving the additional water. It also interrupts the transport of sediment as the catchment losing water may now be unable to carry its sediment load and deposit it. This can decrease the channel capacity and increase the risk of flooding locally. The catchment receiving the increase in flows may have greater velocities (i.e. the speed the water moves down the river) and hence encourage erosion which can affect bank stability and undermine in-stream structures.

Pumping water from mines and quarries can also keep rivers artificially high. During mining works channel diversions, interception of groundwater flow paths i.e. day level from historic mining, and surface water collecting in the void can all be re-routed into a nearby watercourse. After works have been completed, untreated groundwater can resurface uncontrolled and affect property and infrastructure as well as polluting the watercourse. Therefore, continued pumping can be used to intercept the rebounding groundwater to ensure pollution and flood risk issues are mitigated. In addition, any temporary increase in flows e.g. works that require a drawdown of a reservoir, can increase flood risk downstream as high water levels could coincide with a rainfall event.

Any increase in flow to a watercourse will increase the flood risk downstream. Therefore, an assessment should be undertaken to identify the vulnerable receptors and establish at what level flooding occurs. Dependent on the assessment, a cessation of pumping may be triggered manually or automatically through the use of a telemetry system when the river reaches a certain predetermined level. Note that any manual system is reliant on human intervention and therefore makes the system more vulnerable to failure.

Discharge alterations and flood risk best practice

- Should not increase flood risk elsewhere.
- Assessment should be made of the vulnerable receptors downstream including infrastructure, property, and health and safety.
- Long-term solutions to the potential increase in flood risk should be investigated.

Guidance documents

- WAT-RM-01: Regulation of Abstraction and Impoundments
- WAT-RM-11: Licensing Groundwater Abstractions, including dewatering

In-stream structures, impoundments and ponds

In-stream structures, e.g. weirs, groynes, croys, log jams, and flow deflectors, are used to control water levels to enable water abstraction, allow navigation, influence flooding, measure discharge, stabilise erosion features, or trap sediment. Any in-stream structure will affect the direction and velocity (i.e. the speed the water moves down the river) of flow in a river as these features present an obstacle to the flow. Water will likely back up behind these structures and hence increase water levels locally as well as capturing debris being transported down the river e.g. tree branches. Therefore, an assessment is recommended to investigate the impact that water levels and direction of flow will have on the nearby area. These structures direct flow either away from or towards the banks and therefore additional protection may be required to prevent erosion to the bed or banks. Removal of in-stream structures may also have an impact on water levels and therefore consideration of any change in flow, water levels, and erosion and deposition is recommended.

Off-line ponds can offer a mechanism to store water and therefore reduce flood risk downstream of the site. The construction of an off-line pond to store flood water will require consideration of the inlet and outlet which enables the transfer of water to the storage area e.g. via pipe or spillway, and then back into the watercourse. This will require an assessment of what level the storage area will be designed to flood and what volume will be stored off-line before being safely returned to the river. The type of pond will also require consideration i.e. will it be raised up above ground level and require an embankment or will it be located below ground level. The construction of any embankment increases water levels above ground level and hence the risk of flooding downstream from breach or failure. Depending on the size of the structure, it may fall under reservoir legislation. During the construction of any pond, spoil material should not be deposited on the floodplain as it infills an area of floodplain and could be mobilised during a flood event and impact areas downstream.

Note that SEPA has a general presumption against the construction of on-line, stream fed ponds. From a flood risk perspective, they offer very little in the way of flood alleviation as the volume of potential storage may already be filled prior to the onset of a flood event.

In-stream structures and flood risk best practice

- Assess the impact the structure will have on water levels.
- Assess the potential erosion and depositional changes as a result of the in-stream structure construction/ removal. This can affect flood risk elsewhere by blocking structures or eroding embankments that provide protection to existing properties and infrastructure. For example, any nearby bridges should be considered to ensure there is no undermining of the piers.
- There should be a period of post development monitoring to ensure that the engineering works have the desired effect and are not causing problems flood risk issues elsewhere.
- Built with an awareness of potential breach or failure implications.

Ponds and flood risk best practice

- Material excavated from the pond should be appropriately disposed of outwith the floodplain.
- The inlet and outlet structure should be designed to operate correctly during high flows.

- An understanding whether the pond will fall under the Reservoirs Act and designed accordingly.
- There should be an appropriate spillway or outlet to cope with flood events exceeding the design standard.

Guidance documents

- Ponds, Pools, and Lochans (2000)
- Reservoirs (Scotland) Act 2011
- CIRIA C551: Manual on Scour at Bridges and Other Hydraulic Structures

Natural flood management

As defined within the Flood Risk Management (Scotland) Act 2009, natural flood management includes the retention of floodwater e.g. floodplain, woodlands, and wetlands, or the slowing of flood water e.g. woodland and other vegetation. The concept of slowing down the flow by its nature involves the raising of water levels. We would stress that current understanding of the benefits that can be realised by incorporating natural features into flood mitigation measures is still in its infancy. Therefore, it should not be solely relied upon to protect an area from flood risk.

Any inclusion of vegetation or woody debris e.g. tree roots, woven willow, or log jams, into a river or floodplain has the potential to exacerbate flood risk as it can be mobilised during a flood event and become trapped at downstream bridges or culverts. Also it can direct water towards banks thus increasing the potential for erosion. Therefore, careful consideration should be given to the placing and securing of any material.

Forest and woodlands have long been associated with an ability to slow down run-off and reduce downstream flooding. Despite the widespread belief that replanting or creating new woodlands offer opportunities to reduce flood risk, their effectiveness is significantly dependent on a number of important factors such as scale of forest cover, location within the landscape, forest type, and forest management. The size and steepness of catchments are also critical meaning any results gleaned from lowland catchments may not be applicable to more upland catchments and vice versa. We stress caution regarding any plans that incorporate the use of trees and woodlands to reduce downstream flood risk. Consideration should be given to the length of time it takes for the trees to reach maturity.

The removal of embankments to engage the watercourse with its floodplain should only be undertaken if an assessment has shown that there will be no increase in flood risk elsewhere. Studies within Scotland have shown that rural embankments can hold water back during large flood events before slowly releasing the water back into the river and have provided some positive benefit to downstream communities. Further information on embankments can be found in the Embankments and walls Section (hyperlink).

For channel re-meandering see the advice provided in Diversions and Realignments Section (hyperlink).

Natural flood management and flood risk best practice

- Investigation into alternative activities that may achieve similar or better results.
- Ensure there is no downstream blockage potential if material is mobilised.
- Consider the potential for a pulse of water to travel downstream should there be a failure of the structure and the implications associated with it.
- Avoid altering the behaviour of the river which may result in downstream flood peaks coinciding with one another and worsen flooding elsewhere.
- Materials should be appropriately secured to the bed and banks of the river.

Guidance documents

- Managing Woody Debris in Rivers, Streams & Floodplains
- Environmental Agency: Working with Natural Processes to Manage Flood and Coastal Erosion Risk (2010)
- Natural Flood Management Position Statement
- Working with Nature to Manage Flood Risk