SEPA
Scottish Environment Protection Agency

Identifying Opportunities for Natural Flood Management

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Contents

1. Introduction

The Flood Risk Management (Scotland) Act 2009 (FRM Act) places a focus on a more co-ordinated, integrated and sustainable approach to flood risk management in Scotland. It requires us to be more proactive, targeting actions to where the risk is greatest and managing whole flooding systems, be they catchments or coastlines. A key element of sustainable flood risk management involves finding ways to manage the source and pathway of flood waters, rather than solely focusing on traditional hard engineering further down the catchment.

As part of this approach SEPA is required to consider whether techniques that work with natural features and characteristics can contribute to managing flood risk. These techniques are often referred to as natural flood management (NFM). Natural flood management seeks to store or slow down flood waters through measures such as the planting of woodlands, wetland creation, river restoration, or the creation of intertidal habitats. In addition to flooding benefits, NFM measures can also provide many additional benefits to biodiversity, water quality and recreation. These measures may be particularly appropriate where hard defences are inappropriate or as a complement to such defences, making them more resilient to climate change.

The production of natural flood management maps, a requirement of section 20 in the FRM Act, has resulted in the first national source of information on areas where NFM would be most effective within Scotland. The maps are part of a suite of tools which will be used in the Flood Risk Management Planning Process to help us produce Scotland’s first set of national co-ordinated strategies and plans to manage flooding.

2. Identifying opportunities for natural flood management

SEPA's assessment of opportunity areas for natural flood management is a high level strategic analysis of areas within Scotland where the implementation of NFM measures would be most effective. The outputs of the analysis will be used to help SEPA and local authorities identify which NFM measures to take forward through the FRM Strategies and Local FRM Plans. The information produced by this assessment will also provide valuable information for land use planning and river basin planning.

It is important to note that the maps do not consider flood risk or directly recommend which specific NFM measure should be implemented where. The outputs instead provide an indication of where more detailed assessment of opportunities for NFM should be focused. SEPA and the local authorities will carry out this more detailed assessment using information such as the location and nature of flood risk, current land use, and existing defences to identify individual measures.

In 2012, SEPA and Forestry Commission Scotland commissioned a study to identify an approach to undertake a national screening of opportunities for NFM [1]. Based on the recommendations provided, and in consultation with a number of organisations and stakeholders (including the Scottish Advisory and Implementation Forum for Flooding (SAIFF) and the Centre of Expertise for Waters (CREW)), SEPA has produced five maps showing areas where there are opportunities for:

- runoff reduction;
- floodplain storage;
- sediment management;
- estuarine surge attenuation; and
- wave energy dissipation.

The maps have been produced for all of Scotland, with the exception of the map showing opportunities for sediment management which has been produced for those catchments greater than 10km^2 containing a Potentially Vulnerable Area (PVA) only. The NFM techniques which may be appropriate in the opportunity areas identified by each of the maps are detailed in Table 1.

Table 1: NFM techniques relevant to each map

NFM Map	Technique
Runoff reduction	Woodland planting (including upland, floodplain, riparian, gully or cross slope woodlands)
	Creation/restoration of non-floodplain wetlands

[1] Nutt, N. 2012. Flood Risk Management (Scotland) Act 2009. Methods to screen and quantify natural flood management effects. Report commissioned by SEPA and Forestry Commission Scotland, May 2012.

NFM Map	Technique
	Agricultural and upland drainage modifications (e.g. upland drain blocking)
	Land and soil management practices (e.g. ploughing along the contour of the land or soil aeration)
Floodplain storage	Reach and floodplain restoration
	Floodplain and riparian woodlands
	Instream structures (e.g. large woody debris and boulders)
	Reach restoration (e.g. remeandering)
	Offline storage areas and washlands
Sediment management	Reach restoration (e.g. remeandering)
	Sediment traps
	Bank restoration (e.g. riparian planting, green bank restoration)
Estuarine surge attenuation	Restoration of intertidal habitats including managed realignment
Wave energy dissipation	Beach management (e.g. beach recharge)
	Sand dune restoration
	Restoration of intertidal habitats including managed realignment

2.1. Opportunity areas for runoff reduction

When rain hits the ground some of it travels overland and downhill as runoff. This runoff plays an important part in flooding since a proportion of it will be transferred to rivers within the valleys of the landscape. The amount of runoff that makes its way to rivers is influenced by many factors including the slope of the land, the extent to which the soils allow infiltration of water and the way the land is used. NFM measures to reduce runoff typically involve the planting of trees but can also include measures that increase the ability of the land to store water such as upland drain blocking or soil aeration (Table 1). Trees reduce runoff by intercepting rainfall and then increasing the extent to which the land can store any water reaching the ground, both by slowing down the flow of runoff and increasing the permeability of soils.

In order to identify where NFM measures would be most effective in reducing runoff, a map has been produced that identifies areas within a catchment which contribute most to the generation of overland flows. The assessment undertaken to produce this map is based on

the Environment Agency's method for the identification of catchments sensitive to land use change[2]. In this method, the potential for runoff reduction is assessed based on:

- land cover;
- soil type;
- slope; and
- long term average rainfall.

A score is assigned to each of these parameters and an average taken of the four. The map, which has been generated for all of Scotland at the resolution of 250m x 250m grid cells, shows areas of medium and high potential for runoff reduction (Figure 1). For example, in an area where there is a lot of runoff (slope is steep and average annual rainfall is high), but where the current land cover and soil type do not allow much water to infiltrate the land, the potential to change the land use to increase runoff reduction will be high.

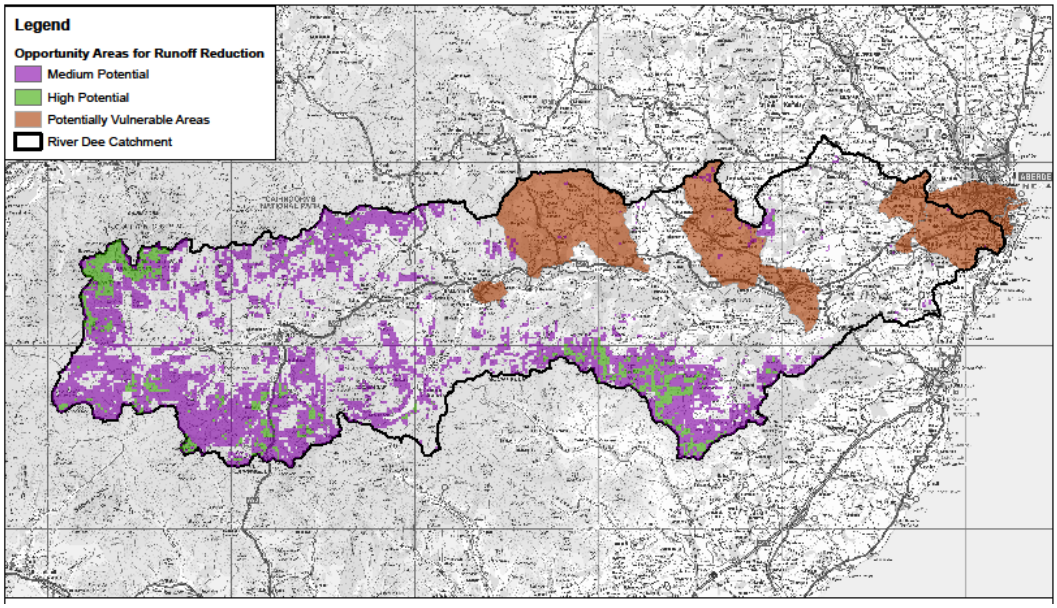

Figure 1. Opportunity areas for runoff reduction (Dee Catchment)

While this map identifies general areas where runoff reduction measures would be most effective, further assessment will be required to identify the precise location and nature of measures. This more detailed assessment will consider the location of flood risk relative to the opportunity areas identified so that measures are targeted to where they can help reduce flood risk. Other key datasets, such as existing land cover, will also be consulted. For example, where riparian or floodplain vegetation is absent in an opportunity area, riparian or floodplain planting may be appropriate. In some catchments, opportunity areas for runoff reduction are located above the altitude at which trees are expected to grow. In these areas, upland drain blocking may be appropriate.

2.2. Opportunity areas for floodplain storage

Floodplains have an important function in both storing and slowing flood waters. In some areas, however, activities to alter the physical shape of the river, such as river straightening

[2] Environment Agency 2008. Delivery of Making Space for Water: Identification of catchments sensitive to land use change NA788.
http://archive.defra.gov.uk/environment/flooding/documents/manage/catchments.pdf

or the building of flood embankments, have reduced the extent to which the river is able to overtop and flood the floodplain. Even where floodplains are still connected to the river, measures such as the removal of woodland may have reduced the extent to which the floodplain can efficiently store water. NFM measures that increase floodplain storage include measures that restore the connection of the floodplain with the river such as through the removal of embankments or reinstatement of old meanders, or restore the floodplain itself such as through floodplain planting (Table 1). Additional flood storage may also be achieved by creating washlands, most commonly by setting back embankments and allowing the floodplain to flood specifically for flood management purposes.

A map has been produced which identifies areas where there is the greatest potential to increase floodplain storage. The assessment undertaken to produce the map considers floodplain slope and land cover, specifically the potential to increase the hydraulic roughness of the land (the amount of resistance water experiences when passing over land). So, for example, an area of floodplain which is gently sloping (and thus has good potential to store water) and for which the land cover can be improved (to something which better holds back the flow of water) would be identified as having moderate or high floodplain storage potential.

The assessment has been carried out on areas of floodplain which have an annual probability of flooding at least once every 200 years. The final output, which has been generated for all of Scotland at the resolution of 250m x 250m grid cells, shows areas of medium and high potential for floodplain storage (Figure 2). It should be noted that while lochs are identified as having storage potential, they are unlikely to be suitable locations for implementing NFM.

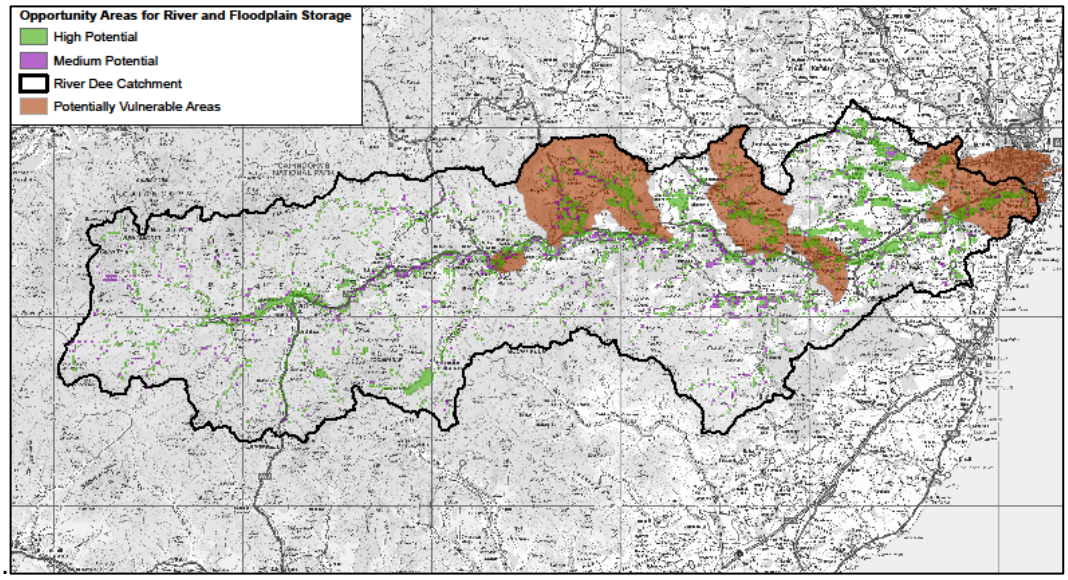

Figure 2. Opportunity areas for floodplain storage (Dee Catchment)

More detailed assessment of the specific locations and nature of measures to take forward will require reference to not only flood risk and land cover but information on the whether the floodplain is currently connected to the river. For example, there may be an embankment that is no longer required than can be removed to increase connectivity. Information on whether the course of the river has been altered, e.g. straightened, will also be useful in identifying opportunities to restore the natural course of the river (e.g. through restoring meanders) and in so doing increase the extent to which the river can overtop and store water on the floodplain.

2.3. Opportunity areas for sediment management in rivers

Sediment is naturally eroded from the beds and banks of rivers and transported downstream, particularly during high flows and floods. Once the sediment reaches an area where the flow is slower and the river bed is flatter (an area of lower energy), the sediment is deposited. This process is repeated when, during the next period of high flow, the sediment is picked up and moved downstream once more (Figure 3).

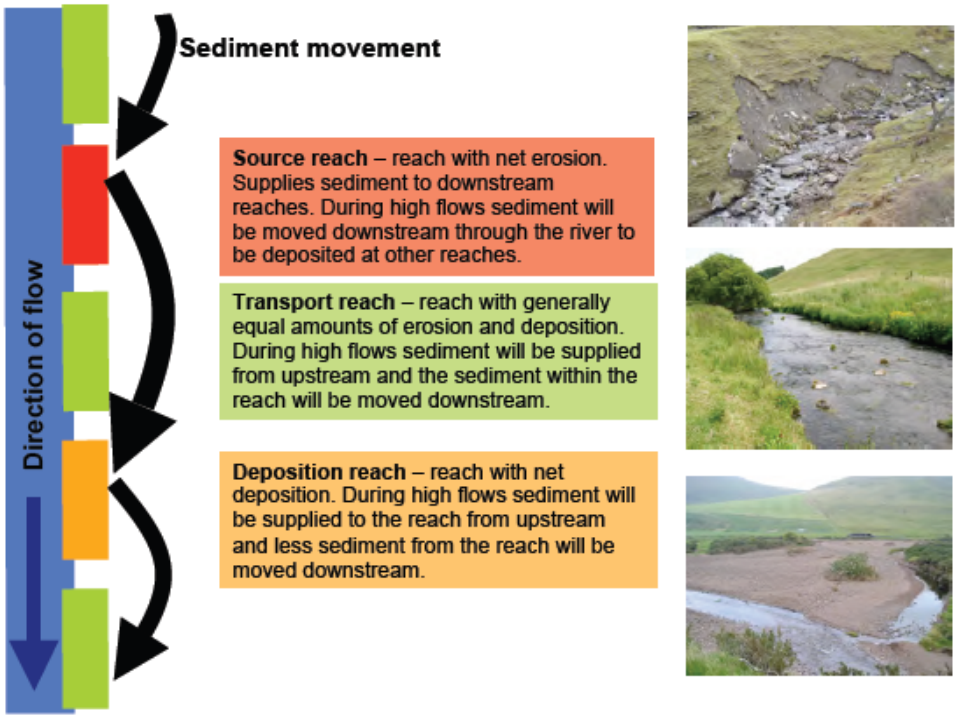

Figure 3. The movement of sediment through a river system

Normally, a river will naturally change its shape to accommodate the amount of sediment moving through it. However, activities such as sediment removal or the straightening of the river channel may disturb natural processes and can cause excessive erosion or deposition of sediment. Land management activities on surrounding land may also contribute sediment to the river in the form of sediment laden runoff. Excessive deposition of sediment is a particular problem for flood risk management as it reduces the capacity of the river to transport water and may result in overtopping and flooding. Flood risk may also be increased in areas of high erosion where banks are retreating towards receptors such as property.

In order to identify where sediment management measures may be appropriate to help reduce flood risk, an assessment of sediment transport has been carried out, using a model developed at the University of Nottingham[3] and further developed and validated by SEPA. By estimating the amount of sediment entering a reach with the amount of sediment leaving that reach, the model identifies whether a river reach is a source of sediment (and thus eroding), depositing sediment or transporting sediment (neither eroding or depositing sediment). The map has been generated for those catchments greater than 10km^2 containing a Potentially Vulnerable Area (PVA). River reaches are classified as areas of

[3] Parker, C. 2010. Quantifying catchment-scale coarse sediment dynamics in British rivers. Ph.D.Dissertation Thesis, University of Nottingham, Nottingham.

high deposition of sediment, moderate deposition of sediment, transporting sediment, moderate erosion of sediment or high erosion of sediment (Figure 4). Due to the nature of the assessment, it has not been possible to generate an output for the top or bottom reaches of a water body and consequently these reaches are classed as having 'no data available'.

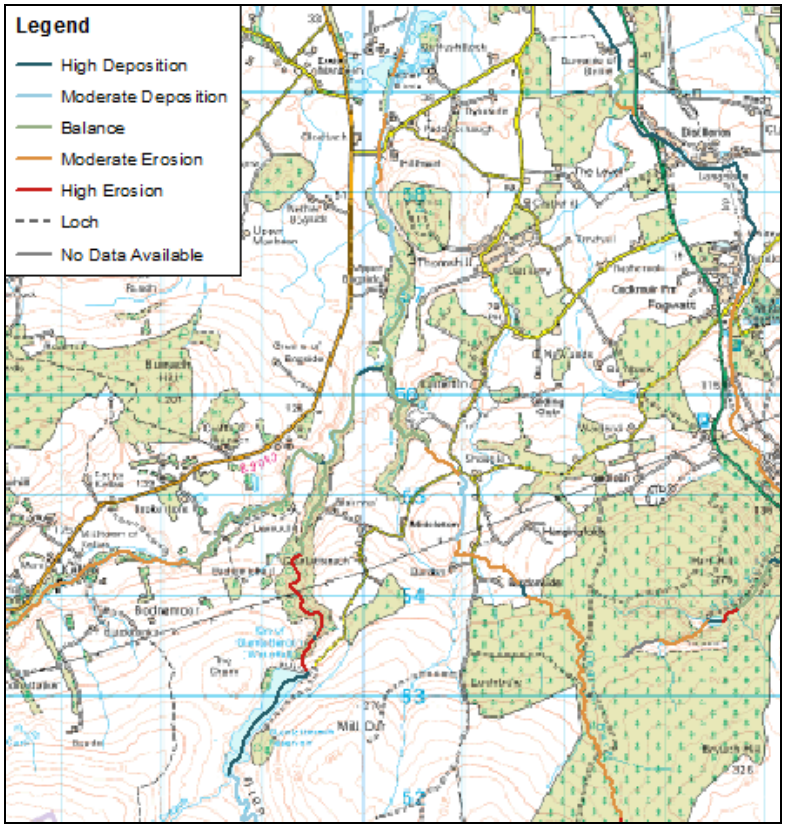

Figure 4. Opportunity areas for sediment management

When identifying measures to tackle flooding associated with sediment deposition (Table 1), it will be important to establish the source of sediment rather than just removing the sediment at the point of deposition. SEPA's Morphological Pressures Database includes records of areas of high erosion for some rivers and this will be consulted to provide further information on the source of sediment in high erosion reaches, e.g. where bank protection works may be appropriate. Information on surrounding land cover/use and alterations to the shape of the river will also be important in determining whether sediment deposition may be addressed through improved land management practices or the restoration of the river to its natural course (e.g. remeandering).

2.4. Opportunity areas for estuarine surge attenuation

Surge, a key component of coastal flooding, results when low atmospheric pressure combines with high winds to increase sea level and propel water onshore.
NFM measures that can help reduce the effects of flooding from surge (Table 1), typically involve the creation of intertidal habitat, such as salt marsh or mudflats, most commonly through the breaching or removal of coastal defences (managed realignment). Inundating the land in this way allows the habitat to re-establish and in so doing, provides an area that can reduce (attenuate) the force of the surge.

In order to identify areas where measures to attenuate surge, such as the restoration of intertidal habitat, would be most effective, a map has been produced showing areas where estuarine surge is greatest. The map has been produced using data from SEPA's assessment of coastal areas which have a probability of flooding at least once every 200 years. Specifically water depth data from this assessment has been used to give an indication of where surge would be high. The final output, which has been generated for areas classified as estuaries under the Water Framework Directive at the resolution of 100m x 100m grid cells, shows areas of medium and high potential for estuarine surge attenuation (Figure 5).

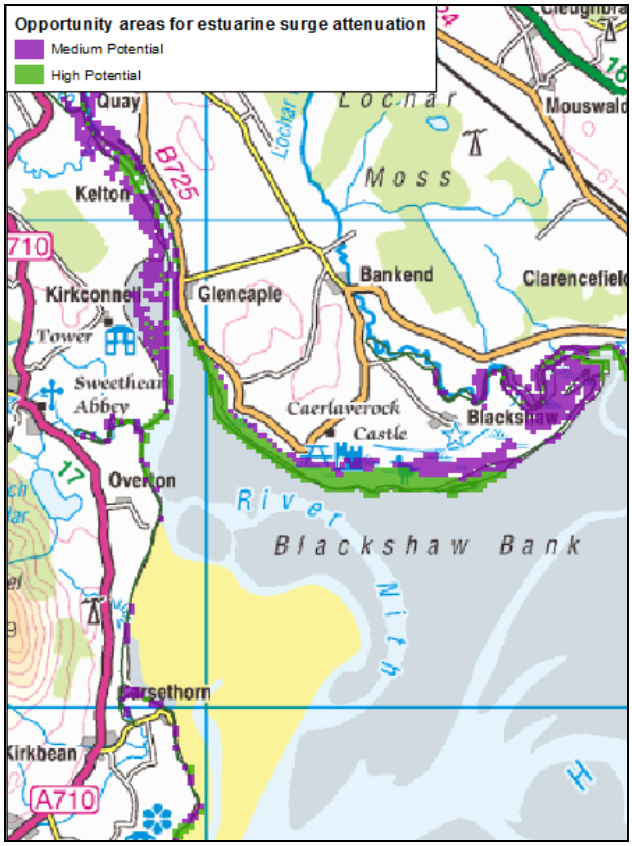

Figure 5. Opportunity areas for estuarine surge attenuation (Nith estuary)

Intertidal habitat restoration is most appropriate where water is at risk of breaching coastal protection and flooding low lying areas of reclaimed land. Consequently more detailed assessment of the location of measures to attenuate surge will need to consider land cover, the presence and condition of coast protection or flood protection schemes and whether the area can be allowed to flood. Strategic flood risk appraisals, and any other projects or studies on coastal flooding or restoration, including information in Shoreline Management Plans or equivalent will also be important sources of information.

2.5. Opportunity areas for wave energy dissipation

In addition to sea level rise associated with estuarine surge, coastal flooding can also result from waves moving inland on an undefended coast or overtopping or breaching coastal protection. A number of NFM measures can be employed to help reduce the effects of flooding from waves, such as sand dune restoration or beach recharge (the importing of

sand to areas where sand has been lost) (Table 1). All of these measures work by dampening or absorbing (dissipating) the force of the waves as they arrive onshore. Such techniques can be used to reduce the flood risk where no protection exists, or supplement existing protection to either extend its lifespan or to increase the standard of protection it provides.

In order to inform the selection of measures to dissipate wave energy, a map has been produced showing areas where opportunities for wave energy dissipation are greatest. The assessment carried out to generate this map considers:

- wave energy; and
- the space available to attenuate wave energy.

Areas have been assessed as having potential for wave energy dissipation if the space available for attenuation was comparatively higher than the wave energy in that area. Fetch (the distance over which wind can blow to create waves) has been used as an approximation for wave energy since no sufficiently detailed wave power dataset currently exists for Scotland. Space for attenuation has been calculated as the distance between mean high water spring and mean low water spring; for example, where a cliff exists the space for attenuation will be zero. The map, which has been generated for Scotland's entire coastline, at the resolution of 200m x 200m grid cells, shows areas of medium and high potential for wave energy dissipation (Figure 6).

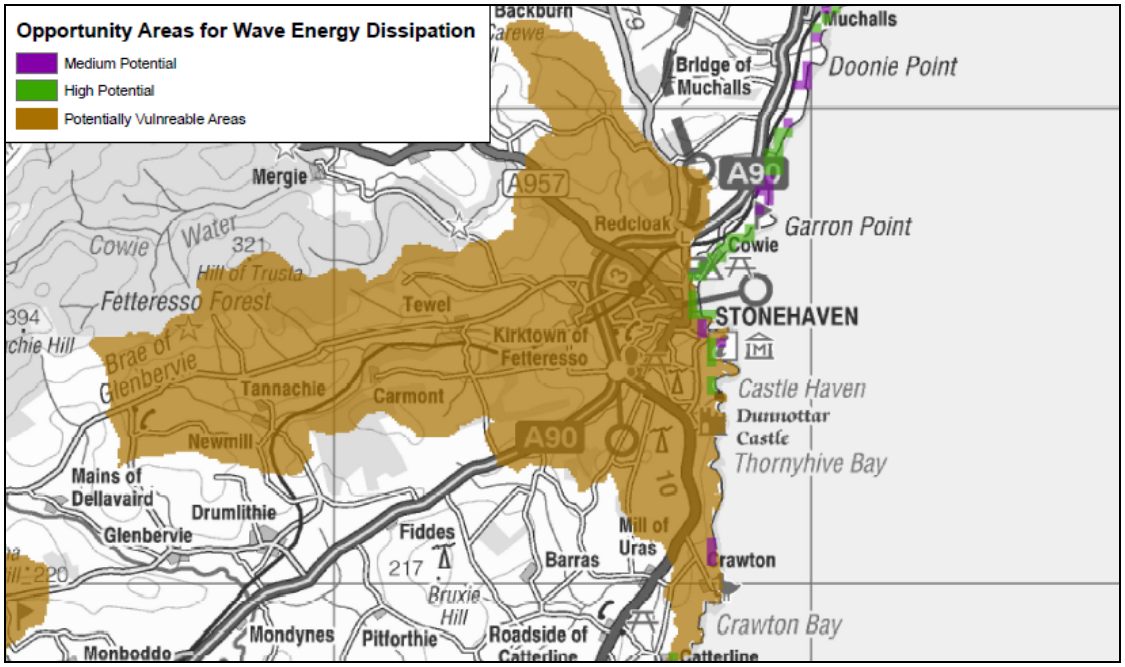

Figure 6. Opportunity areas for wave energy dissipation (Stonehaven coastline)

Detailed assessment of the nature and location of measures to dissipate wave energy will require consideration of similar information to that described above for estuarine surge attenuation, including land cover and the presence and condition of coastal protection. Any coastal NFM measures (including those to address estuarine surge) will need to consider the potential for measures to reduce flood risk as well as the nature of that flood risk, e.g. whether the flooding is a result of direct inundation, coastal erosion, or the breaching or overtopping of existing protection. For example, beach recharge is particularly appropriate where shorelines are suffering erosion as it effectively replaces the sand lost to that erosion and protects sand dunes by increasing wave energy dissipation across the beach.

3. Working with natural processes: next steps

The NFM maps have identified where NFM measures would be most effective in storing or slowing water, or managing instream sediment. SEPA, in consultation with local authorities and other responsible authorities, will consider what measures within these opportunity areas would be most appropriate to help meet the objectives set for the PVAs. An important part of this work will be identifying existing or proposed projects to implement NFM so that linkages are made with work already underway.

NFM measures that are deemed to have the greatest benefit to flood risk will then be screened to remove any that are unfeasible, for example, due to constraints such as infrastructure or the presence of designated sites. SEPA and the responsible authorities, with input from stakeholders, will agree the preferred suite of measures for each PVA, including NFM measures, and detail these in the forthcoming Flood Risk Management Strategies. Consideration of benefits to biodiversity, recreation or water quality will form part of this final selection of measures.

While the NFM maps identify where measures would be most effective, this does not mean that NFM should not be pursued in other areas. It will still be important to identify local opportunities that can deliver local benefits to flood risk as well as the many other benefits associated with NFM.

Local Flood Risk Management Plans, prepared by Local Authorities, will take the NFM measures set out in the Flood Risk Management Strategies and detail how they will be funded and implemented. This may require additional assessment and modelling of individual options. A key element of this process will be engagement with land managers and key stakeholders so that measures can be taken forward with the full cooperation of all interested parties.

Summary of key features of the NFM maps:

- **the NFM maps are strategic high level maps for identifying where NFM measures would be most effective in storing or slowing water, or managing sediment;**
- **they do not relate opportunities for NFM to areas of flood risk or identify which specific measures should be implemented where;**
- **they should be interpreted together with other key data such as information on flood risk, land cover, flood protection and physical alterations to river bodies; and**
- **NFM measures will only be implemented in a small proportion of the areas identified and only with the full cooperation of landowners and key stakeholders.**

SEPA Corporate Office
Erskine Court
Castle Business Park
Stirling, FK9 4TR
Tel: 01786 457700
Web: www.sepa.org.uk