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1. Introduction.

Diffuse pollution of the environment resulting from agricultural activities is increasingly being recognised as one of the more important sources of environmental pollution. A systematic methodology for identifying such risks and for implementing strategies to alleviate problems is urgently needed. For this reason, SEPA has commissioned the preparation of three linked documents, the first setting forth a methodology for diffuse pollution audits on farms, the second a methodology for selecting appropriate measures to address the problems identified in the audits and the third, a catalogue of possible measures.

The guidance included below is meant to help those charged with addressing agricultural diffuse pollution issues in practice. It will prove useful to catchment management planners in priority or problem catchments, to regulators such as Scottish Environment Protection Agency staff and to advisors and consultants to farmers as they try to comply with a support regime which will increasingly stress environmental protection in compliance with government policy. It is meant to supplement and compliment existing advice such as the PEPFAA code, the 4 Point Plan and various farm accreditation schemes, not to replace them. The target is diffuse pollution from agriculture and its control by means of Best Management Practices (BMPs).

The variety of farm and catchment types in Scotland, and the variety of diffuse pollution issues that may be highlighted by the audit process means that it is difficult to provide instruction for every possible scenario that an adviser or consultant may encounter. Six case studies will cover the main Scottish farm types. Within each case study, the findings of the diffuse pollution audit will be discussed in the context of the surrounding catchment. BMPs will then be prioritised and the merits of potential BMP solutions discussed, with a full explanation of the reasoning behind each step in the procedure. The case studies approach will put the guiding principles of the implementation of BMPs into a real-life context. This will make the guidance much more readily accessible than a complex list of instructions for the adviser or consultant in the field, particularly when approaching the decision-making process for the first time.

This guidance is the second of a three part series on addressing agricultural diffuse pollution issues. The first part, "Farm scale diffuse pollution audits", sets out a methodology for carrying out diffuse pollution audits on farms and includes standard audit forms to aid this process. This second part, "Siting and suitability of BMPs" sets out guidance on selection of suitable mitigation measures for problems identified in the audit. The third part, "Handbook of BMPs for the Reduction of Pollutants Emanating from Diffuse Sources into Surface Waters" contains descriptions of a wide range of possible Best Management Practices to address diffuse pollution issues organised in a way to facilitate selection.

With effect from 2005, the granting of the majority of payments under the reformed CAP have been linked to respect of environmental, food safety, animal welfare and plant health standards.

The reform of the Common Agricultural Policy (CAP) and the introduction of the concept of Land Management Contracts (LMC) in January 2005 signalled a major shift in the support of Scottish agriculture with environmental and sustainability issues increasing in profile. Under CAP reform, payments to farmers are decoupled from production. Essentially this means that instead of having to produce crops or livestock to obtain payment of subsidy, farmers receive direct support in the form of a Single Farm Payment (SFP). The LMC concept has three tiers:

Tier 1 – The Single Farm Payment Scheme – This replaces most of the support schemes in the main sectors (arable, beef and sheep) which were in existence pre-January 2005. The receipt of the

SFP will however be conditional on farmers complying with certain conditions known as 'cross compliance'. There are two elements to cross compliance:

1. Statutory Management Requirements - SFP recipients must comply with a number of specified legal requirements, known as Statutory Management Requirements (SMRs). To date there are 15 SMRs contained within cross compliance and include legislation relating to conservation, pollution prevention, identification and registration of animals and disease control.
2. Good Agricultural and Environmental Condition – SFP recipients must keep their land in Good Agricultural and Environmental Condition (GAEC). These factors reflect good practice and include 18 specific measures relating to;
 - Soil erosion – protection of soils.
 - Soil organic matter – maintenance of soil organic matter levels.
 - Soil structure – maintenance of soil structure.
 - Minimum level of maintenance – ensures a minimum level of maintenance and avoids the deterioration of habitats.

These requirements are not expected to change significantly in future years, although a further 3 SMRs relating to animal welfare requirements will be introduced in 2007.

Tier 2 – The LMC Menu Scheme – This is an optional scheme and is open to all IACS registered land managers in Scotland. There are currently 17 options to choose from aimed at delivering widespread benefits leading to economic, social and environmental improvement. Some of the options are one-offs, others such as the agri-environment measures involve a 5 year commitment.

Tier 3 – Development for 2007 - Likely to be based around existing agri-environment/RSS measures.

As far as possible, this guidance seeks to be consistent with and facilitate the delivery of GAEC and cross compliance in Scotland. Addressing diffuse pollution issues is likely to be a feature of all tiers of any contracts post 2007.

To engage farmers fully, the emphasis should be on rewarding good practice, as well as penalising bad practice, through measures within CAP reform in combination with enforcement of domestic legislation. Issues such as diffuse pollution, habitat enhancement, sustainable use of soils and water resources and flood-risk alleviation will require to be actively supported if progress is to be made in delivering on environmental targets and European Directives. In particular, the requirements of the Water Framework Directive, which will set the broad framework for the protection and enhancement of the water environment in the future, will have to be delivered.

1.1. Diffuse pollution.

As point sources of pollution have increasingly been addressed and controls introduced, the relative importance of diffuse sources has increased. SEPA currently estimates that of the waterbodies in Scotland deemed to be 'at risk', diffuse pollution is a primary and/or contributory factor in up to 43% of cases (www.sepa.org.uk/wfd-characterisation). Agriculture is considered to be the predominant diffuse pressure, although not invariably the most severe.

A widely accepted definition of diffuse pollution is as follows: (D'Arcy et al. 2000):

"Pollution arising from land-use activities (urban and rural) that are dispersed across a catchment or subcatchment, and do not arise as a process industrial effluent, municipal sewage effluent, deep mine or farm effluent discharge."

Diffuse pollution therefore comprises true non-point source pollution together with inputs from a multiplicity of minor point sources. Examples of strictly non-point sources are comparatively limited, for example nitrates seeping into groundwater. Most water driven soil erosion results in contamination at a specific point via a rill or gully formed as water traverses fields to a watercourse. Point or non-point is really a matter of scale; a field of improved grassland in an upland rough grazing catchment is a nitrate point source for the underlying aquifer, just as each field drain is a point source for understanding inputs to a ditch or small stream. *Diffuse* is the key idea, rather than *non-point*. In loading terms most diffuse pollution enters watercourses via pipes, channels, gullies and rills, even atmospheric deposition, since it has to be washed from the land surfaces. The important characteristics of diffuse pollution therefore are NOT whether anyone can find the source/s, or whether a pipe is involved.

A useful way of thinking of diffuse pollution is that it is the often individually minor but collectively significant sources in a catchment. That is the key to the control options too; measures need to be focused on the land-based activities, rather than on the point of discharge (see Campbell et al. 2004).

Diffuse pollution is a useful concept because it allows for estimation of important loads of pollutants in water bodies that are not from major industrial process and municipal effluent discharges (that are typically well characterized, monitored and quantified). The concept is also useful because it explains features of pollution in receiving water bodies. For example, why concentrations of some pollutants actually increase with flow rather than are diluted, why pollution peaks are variable and difficult to predict, and why impacts are often slow to develop and become evident years later (e.g. contamination of groundwater, changes in trophic status of lochs).

1.2. Best Management Practices (BMPs)

Diffuse pollution sources are frequently individually relatively minor in nature. It is the combination of large numbers of such sources across a catchment that can cause problems. Because each source may be small, they can easily be overlooked. For this reason, an audit approach must be adopted to determine whence diffuse pollution problems arise. Because the problem is generally caused by the accumulative effect of a large number of sources across a catchment, a catchment wide approach is needed to address diffuse pollution issues. The methods being promoted here are referred to as "Best Management Practices" or BMPs. They are applied at an individual farm or field level in order to address diffuse pollution issues that cumulatively give rise to problems at a catchment level.

The following definition of Best Management Practices was published in Novotny and Olem (1994):

"Best Management Practices (BMPs) are methods, measures, or practices selected by an agency to meet its nonpoint (diffuse) source controls needs. BMPs include, but are not limited to, structural and nonstructural controls and operations and maintenance procedures. BMP can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants from diffuse sources into receiving waters."

The third part of this series, “Handbook of BMPs for the Reduction of Pollutants Emanating from Diffuse Sources into Surface Waters” describes a series of Best Management Practices to address a wide range of agricultural diffuse pollution issues.

Diffuse pollution problems may arise at various points in a farming system. BMPs have therefore been devised to address problems at a number of points. These include:

- Planning measures
- Steading measures
- In field measures
- Riparian measures

A treatment train approach is frequently adopted whereby any given diffuse pollution issue is addressed by a series of BMPs acting at different points in the pollution process. For example, a soil erosion problem might be addressed at the planning stage by adopting crop rotations less susceptible to erosion, at the field stage by adopting conservation tillage techniques and at the riparian stage by leaving buffer strips between fields and water courses.

Not all BMPs are free from risks. Some, while addressing one problem may exacerbate another. For example, while injecting slurry into soil may reduce losses of ammonia to the atmosphere it may also increase the risk of nitrogen leaching, particularly if the land has underdrainage. Care should be taken to avoid such “pollution swapping” problems as far as possible.

2. Assessing the significance of diffuse pollution risks.

2.1. Prioritisation of BMPs

Determining the siting and suitability of BMPs as mitigation for diffuse pollution risks requires a structured approach:

- (1) Most importantly the diffuse pollution risks must be prioritised in light of the diffuse pollution audit, because appropriate BMPs will first and foremost be determined by the problem and will be very different, for example, for eutrophied lochs than for bathing water catchments.
- (2) BMPs appropriate to the risks identified must be selected.
- (3) Other factors must be taken into account, such as cost effectiveness, habitat benefits and the likely level of BMP participation across a catchment.

In the absence of data on the source strengths of pollutant loads prioritisation will undoubtedly be subjective to some degree. However, the methodology of impact prediction developed for Environmental Impact Assessment (EIA) provides a relatively objective framework to support the decision-making process. This method aims to assess the **significance** of impacts on the environment based on most notably the **sensitivity** of the environmental resource, and the perceived **magnitude** of the impacts on that resource. The process avoids any sort of numerical scoring, and still requires a good deal of reasoned professional judgement, but can be used to determine broad significance 'thresholds' which allow prioritisation of mitigation measures.

Magnitude	Sensitivity		
	Low	Medium	High
High	Moderate	Substantial	Substantial
Medium	Slight	Moderate	Substantial
Low	Slight	Slight	Moderate

Table 1 Impact Significance based on Sensitivity of Receptor and Magnitude of Impact

2.2. Sensitivity.

For the purposes of assessing diffuse pollution impacts, the sensitivity of the environmental resource and the likely magnitude of the impact must be considered for each pollutant in turn. Sensitivity may be determined at a catchment scale or by some factor specific to the farm (e.g. the presence of a neighbouring designated site or the soils present on the farm). Before undertaking any field work, an assessment should be made of the catchment containing the farms in question. Certain catchments will be more sensitive to certain pollutants and it is important that an appreciation of such sensitivity is built into the subsequent field work. Some catchments will be more prone to certain types of diffuse pollution and this too should be bourn in mind when surveying. In other cases there are specific features such as Sites of Special Scientific Interest within the catchment that require to be taken into account. The "Farm scale diffuse pollution audits" guidance gives examples of specific catchment sensitivities to each pollutant.

Examples of differing levels (High – Medium - Low) of environmental sensitivity to each diffuse pollutant are given below in order to aid in prioritisation of BMPs:

Phosphorus (P)

Drainage to oligotrophic or mesotrophic loch with a conservation designation (e.g. SSSI, Natura 2000) - **HIGH**

Drainage to similar loch without a conservation designation – **MEDIUM**

Soils of low P status – **LOW**

Nitrate (NO₃)

Farm with predominantly sandy or shallow soils within an NVZ - **HIGH**

Farm with heavy soils in an NVZ or farms with sandy soils, outside NVZ – **MEDIUM**

Farm with heavy soils, outside NVZ – **LOW**

Faecal Indicator Organisms (FIOs)

High rainfall areas - **HIGH**

Drainage to designated bathing waters or with drinking water extraction – **HIGH**

Drainage to other recreational waters – **MEDIUM**

Suspended solids (SS) (note, suspended solids are often the agent carrying other pollutants, these are dealt with elsewhere)

Farm with gravel-bed streams within important salmon and sea trout catchments - **HIGH**

Farm with or near gravel-bed streams in other catchments – **MEDIUM**

Farm without gravel-bed streams- **LOW**

Pesticides

Farm drained by small watercourse into an area important for fish or aquatic wildlife - **HIGH**

Farm drained by large watercourse with little evidence of pesticide damage- **LOW**

2.3. Magnitude of impacts.

The magnitude of each diffuse pollution impact is less likely to be determined by overall catchment characteristics and more by individual farming practice and dependant on the problems and other features specific to the farm that will be highlighted by “Farm scale diffuse pollution audit”.

Examples of differing magnitudes (High - Medium - Low) of impact for diffuse pollutants are given in order to aid in prioritisation of BMPs:

Phosphorus

Large poultry and pig enterprises where large amounts of P-rich feed are brought in - **HIGH**

Vegetable growing area with high P soil status - **HIGH**

Arable area with soils and topography susceptible to erosion - **HIGH**

Beef and sheep farm on low P soils and producing FYM – **LOW**

Nitrate

Arable farm with more than 50% of land ploughed and cropped in Autumn - **HIGH**
Mixed beef and spring cropping farm – **LOW**

Faecal Indicator Organisms (FIOs)

Intensive livestock rearing - **HIGH**
Arable farm with no livestock - **LOW**

Suspended solids

Predominantly arable farming, steep land and fine sandy loam topsoils- **HIGH**
Large number of unfenced watercourses with poaching - **HIGH**
Permanent grassland, gently sloping land, all watercourses fenced- **LOW**

Pesticides and veterinary medicines

Field vegetables- **HIGH**
Organic farms - **LOW**

2.4. Significance.

Once sensitivities and magnitudes have been assessed, the matrix approach shown in Figure 1 allows an appraisal of the overall significance of different pollution risks.

Taking examples given in the two previous sections:

Nitrate

A farm with predominantly sandy or shallow soils within an NVZ (**HIGH** sensitivity), where more than 50% of land is ploughed and cropped in Autumn (**HIGH** magnitude), would be expected to have a **SUBSTANTIAL** risk of nitrate diffuse pollution into groundwater.

A mixed beef and spring cropping farm (**LOW** magnitude), with predominantly sandy or shallow soils within an NVZ (**HIGH** sensitivity), would be expected to have a **MODERATE** risk of nitrate diffuse pollution and would therefore be a lower priority for nitrate-targeted BMPs.

Suspended solids

Mixed sheep and arable farm on Old Red Sandstone soils (**HIGH** magnitude) with a burn containing salmon gravel beds (**HIGH** sensitivity), would be expected to have a **SUBSTANTIAL** risk of pollution with suspended solids.

By carrying out this type of appraisal for each diffuse pollutant, the pollutants can be prioritised and BMP selection can proceed.

3. Selecting appropriate BMPs.

3.1. Introduction

Once the significance of the potential impact of each diffuse pollutant has been identified, the pollutants can be listed in order of priority. Appropriate BMPs should then be selected from the "Handbook of BMPs" ([link to website when available](#)) for each pollutant, starting with the highest priorities. When choosing BMPs, consideration should be given to methods that are effective against a number of different pollutants, particularly if they are of high priority on the farm in question. Measures targeted at more than one point of intervention are desirable, since no single measure is likely to be 100% effective for all the pollutants associated for the particular land-use. The treatment train concept is therefore applied in assigning suites of measures (Figure 1).

BMPs have been devised to address problems at a number of points. These include:

- Planning measures
- Steading measures
- In field measures
- Riparian measures

The "Handbook of BMPs" is split into these four sections. BMPs within each section are then listed in order of their point of intervention in the run-off / erosion process as follows:

- a) BMPs that aim to reduce the amount of a pollutant added to the land;
- b) BMPs that aim to reduce the amount of particles which are dislodged from the soil surface;
- c) BMPs that reduce the amount of particles transported from their source to the river;
- d) BMPs which delay the run-off time and reduce the peak flow of run-off;
- e) BMPs to trap pollutants carried in run-off before it reaches the river; and
- f) In-stream amelioration techniques.

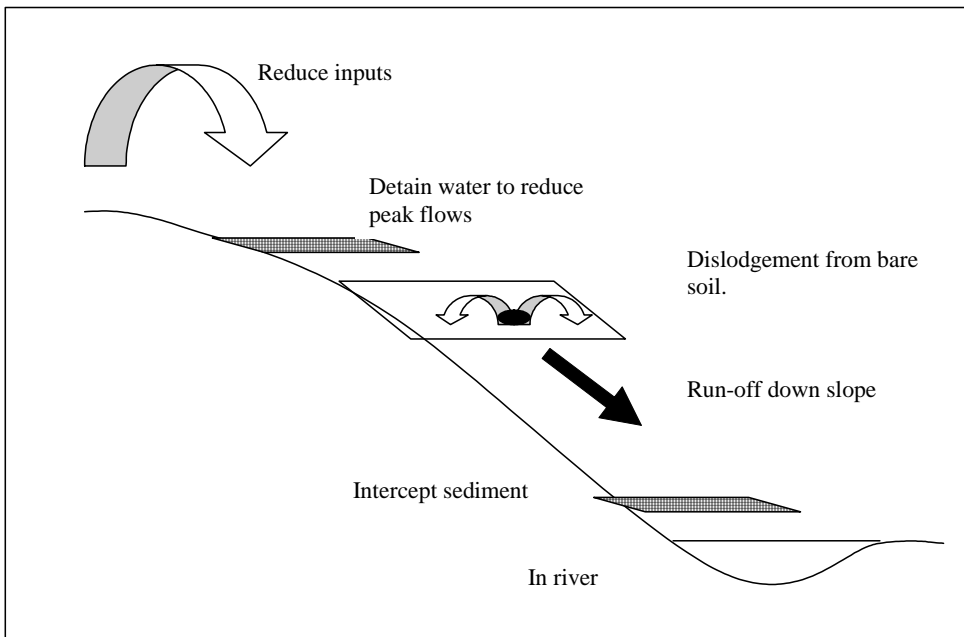


Figure 1. Processes that need to be considered in determining the most appropriate BMP.

2.2. Potential impact of each BMP.

BMPs are listed below along with the diffuse pollutants that they are likely to be effective against. Potential impact of each BMP is assessed as ++ = strong positive effect; + = positive effect; 0 = no effect; - = negative effect; and +/- = uncertain or variable effect. This assessment scheme was used by Dampney *et al.* (2002) and in Vinten *et al.* (2004).

Planning

	BMPs to reduce pollutant inputs	P	NO₃	FIO	NH₃	BOD	SS	Pesticides
27	Manure sharing scheme	+/-	+/-	+/-	+/-	+/-	0	0
27	Manure incineration	0	0	+	+	+	0	0
14	Composting manures	+/-	+/-	+/-	-	+/-	0	0
8	Reassess the need for continued maintenance dressings of P	+	0	0	0	0	0	0
	BMPs to reduce particle dislodgement							
50	Grazing management	+	+	+	0	+	++	0
55	Vehicle movements	+	0	0	0	0	+	0
29	Critical area planting (changing land use)	++	0	0	0	0	++	0
	BMPs to reduce run-off speed							
64	Hedgerow planting	+/-	0	0	0	0	+	0
	BMPs to reduce peak water flow							
112	Land drainage and maintenance of existing drainage systems	+/-	-	-	+/-	+/-	+	-
	Management plans							
9	Waste (manure) management	++	++	+	+	+	0	0
69	Ditch management	+	-	0	0	0	++	0
70	Hedgerow management	+/-	0	0	0	0	+	0
22	Soil erosion and sediment control plans	++	0	0	0	0	++	0
5	Nutrient management plan	++	++	0	0	0	0	0
46	Irrigation management	+	+	0	0	0	+	+
***	Crop protection plan	0	0	0	0	0	0	++

Steading

BMP no.	BMPs to reduce pollutant inputs	P	NO ₃	FIO	NH ₃	BOD	SS	Pest-icides
60	Reduce run-off onto fields from farm roadways	+/-	+/-	+	0	+/-	+/-	0
BMPs to reduce peak water flow this section will change significantly								
10	Farmyard run-off interception	+	+	++	+	++	+	+
11	Roof run-off interception	+	+	0	0	+	+	+
72	Water retention systems – 2 - Grass waterways or swales	+	+	0	-	0	+	+
73	Water retention systems – 3 - Detention basins not sure appropriate	++	+	++	-	+	++	+
74	Water retention systems – 4 – Retention ponds	++	+	++	0	+	++	+
BMPs to intercept pollutants								
107	Use of "Biobeds" while filling sprayer	0	0	0	0	0	0	++

In field: Arable

	BMPs to reduce pollutant inputs	P	NO ₃	FIO	NH ₃	BOD	SS	Pestici des
1	Use of soil P analyses to indicate over fertilisation	++	0	0	0	0	0	0
2	Location of the fertiliser closer to the plant root	+/-	+/-	0	0	0	0	0
3	Timing of fertiliser applications – “incidental losses”	+/-	++	0	0	0	0	0
4	Timing of fertiliser applications - Split application/ slow release fertiliser	+/-	+/-	0	++	0	0	0
7	Liming of acid soils to utilise existing P reserves	+	+	0	+/-	0	0	0
12	Prevention of misplaced fertiliser (spills)	+	+	0	0	0	0	0
92	N application rate based on likely crop uptake	0	++	0	+/-	0	0	0
93	Accurate fertiliser spreading	+	++	0	0	0	0	0
94	Account taken of soil derived nitrogen	0	++	0	0	0	0	0
95	Precision farming techniques	+	+	0	0	0	0	+
96	Use of nitrification inhibitors	0	+	0	+/-	0	0	0
97	Application of high carbon to nitrogen mulches	0	+	0	0	0	0	0
100	Accurate pesticide application	0	0	0	0	0	0	++
101	Targeted pest control techniques	0	0	0	0	0	0	++
102	Integrated pest management	0	0	0	0	0	0	++
103	Use of anti-drift agents	0	0	0	0	0	0	+
104	Use of spray adjuvents	0	0	0	0	0	0	+
105	Novel seed treatments	0	0	0	0	0	0	+
108	Proper disposal of excess chemical and tank washings	0	0	0	0	0	0	++
109	Low volume sprayer washing	0	0	0	0	0	0	+
BMPs to reduce particle dislodgement								
31	Green manure cropping	+/-	+/-	0	0	0	+/-	0

32	Grassland rotation	+	+/-	+/-	+/-	0	++	0
33	Cover crops	+	+/-	0	0	0	+	0
34	Consideration of the time of planting	+/-	+/-	0	0	0	+	-
35-42	Conservation tillage	+	+	0	0	0	+	0
44	Use bulky organic manures and/ or incorporate straw residues	+	+	0	0	0	+	+/-
45	Under sow cover crop	+	+/-	0	0	0	+	0
53	Access tracks/roads	+/-	+/-	+/-	0	+/-	+	0
54	Field boundary/access points	+/-	+/-	+/-	0	+/-	+/-	0
61	Rough ploughing/cultivation in late autumn	+	-	0	0	0	+	0
62	Strip cropping	+	+/-	0	0	0	+	0
110	Avoid too fine seedbeds	++	0	0	0	0	++	0
111	Chemical soil stabilisation	+	0	0	0	0	+	0

BMPs to reduce run-off speed

43	Compaction management	+	+/-	0	0	0	+/-	0
63	Contour cropping	+	0	0	0	0	+	0
65	Terracing (or contour bunds)	+	0	0	0	0	+	0
66	Contour cultivations	+	0	0	0	0	+	0
67	Soil berms (low ridges to divert water flow)	+	0	0	0	0	+	0
68	Intersperse grass banks or ditches	+	0	0	0	0	+	0

BMPs to intercept pollutants

81	Intercept flow at the bottom of a slope by a grass buffer zone	+	0	0	0	0	+	0
82	Focus run-off into buffer zones at critical places on a slope	+	0	0	0	0	+	0
83	Water diversions	++	0	0	0	0	++	0

In field: Livestock

BMPs to reduce pollutant inputs		P	NO₃	FIO	NH₃	BOD	SS	Pesticides
3	Timing of fertiliser applications – “incidental losses”	+	++	0	0	0	0	0
4	Timing of fertiliser applications - Split application/ slow release fertiliser	0	+/-	0	0	0	0	0
6	Reduction in the dietary P by livestock	+	0	0	0	0	0	0
12	Prevention of misplaced fertiliser (spills)	+	+	0	0	0	0	0
24	Incorporation of manures	+	+/-	+	++	+	0	0
25	Manure injection	+	+/-	+	++	+	0	0
48	Feed/water trough location	++	+	++	0	+	++	0
49	Livestock trails	+	+	+	0	+	+	0
93	Accurate fertiliser spreading	+	++	0	0	0	0	0
96	Use of nitrification inhibitors	0	+	0	+/-	0	0	0
98	Manipulation of animal diets to reduce P input (phytase treatment)	+	0	0	0	0	0	0

99	Treatment of animal manures to reduce phosphate availability (alum treatment)	+/-	0	0	0	0	0	0
106	Good practice in sheep dipping	0	0	0	0	0	0	++
114	Spreading manures and slurries in appropriate weather conditions	++	++	++	+	++	0	0
47	Livestock exclusion	+	+	+	0	+	+	0
51	Reduce strip grazing of fodder crops	+	0	0	0	0	+	0
52	Location of outdoor pigs to minimise the risk of erosion	+	+	+	0	+	+	0

BMPs to reduce particle dislodgement

53	Access tracks/roads	+/-	+/-	+/-	0	+/-	+	0
54	Field boundary/access points	+/-	+/-	+/-	0	+/-	+/-	0
113	Avoidance of over-grazing	+	0	0	0	0	++	0

BMPs to reduce run-off speed

43	Compaction management	+	+/-	0	0	0	+/-	0
65	Contour bund	+	0	0	0	0	+	0

In field: Woodland

BMPs to reduce pollutant inputs

	P	NO₃	FIO	NH₃	BOD	SS
4	Timing of fertiliser applications - Split application/ slow release fertiliser	+/-	+/-	0	0	0
12	Prevention of misplaced fertiliser (spills)	++	++	0	0	0
13	Pre harvest and harvest planning of timber felling					
56	Timber harvesting (traditional felling techniques)					
57	Tree felling - cut-to-length harvesting					

BMPs to reduce particle dislodgement

53	Access tracks/roads	+/-	+/-	+/-	0	+/-	+
54	Field boundary/access points	+/-	+/-	+/-	0	+/-	+/-
58	Reforestation/forest stand management						

BMPs to reduce run-off speed

65	Contour bund	+/-	0	0	0	0	+
67	Soil berms (low ridges to divert water)						

Riparian

	BMPs to reduce pollutant inputs	P	NO₃	FIO	NH₃	BOD	SS	Pesticides
88	Stream crossing	+	+	+	0	+	+	0
	BMPs to intercept pollutants							
75	Artificial reed beds	+	+	+	-	+	+	+
80	Riparian buffer zones – 3 – dissolved pollutant reduction	+	+	0	-	0	0	+
79	Riparian buffer zones – 2 –solids reduction	+	+/-	0	-	0	+	0
78	Riparian buffer zones – 1 – protection from machinery operation							
76	Wetland restoration	+	++	0	-	0	+	+
	BMPs to ameliorate pollution in-stream							
86	Bank erosion	++	+/-	0	0	0	++	0
87	Stream bank stabilisation	++	+/-	0	0	0	++	0

4. Planning BMPs

4.1. Introduction

Planning BMPs are aimed at matching inputs to crop and grass requirements and managing the land to reduce the risk of potential pollutants entering the water environment. The report to the farmer after completion of the diffuse pollution audit begins with an overall description of the farm and farming system. This is followed with planning and management issues which leads to the first selection of BMPs when recommending a BMP treatment train. This approach is illustrated in the Farm Case Studies in section 10 of this guidance. Planning BMPs are described in section 5 in the guidance on “Farm scale diffuse pollution audits” and are described in detail on individual BMP sheets BMP-5, 9, 22, and 46 in the "Handbook of BMPs". General guidance on implementation of these plans is given below.

4.2. Nutrient Management Plan (BMP-5)

A Nutrient Management Plan should be prepared and implemented on all farms where organic or inorganic nutrients are spread onto the land. When all nutrient input and offtake practices are considered together they constitute a Nutrient Management Plan. The first step is to collect nutrient data in order to prepare a nutrient budget. A data collection scheme for a whole farm nutrient budget is shown at F in the Diffuse Pollution Audit Form. This approach can be used to raise the farmer's awareness of the efficiency, or inefficiency, of the farming system, and the potential for diffuse pollution from surplus nutrients. Many studies have shown that all farm types have the potential to show an annual surplus of P (e.g. SEPA, 2002). A full description and guidance on completing a field and farm scale P nutrient budget is given in section 5.2.2 in the first part of this series, the “Farm scale diffuse pollution audit”. P budgets are also shown in the Farm Case Studies in section 10 of this “BMP siting and selection” guidance. On farms where diffuse pollution from P is a priority, P budgeting should be combined with a Manure Management Plan (BMP-9) on livestock farms and Soil Erosion and Sediment Control Plans (BMP-22).

Preparation and implementation of a nitrogen management plan are mandatory on farms within designated Nitrate Vulnerable Zones (NVZs). Forms for recording details of livestock, crops, N fertilisers and organic manures are provided by the Scottish Executive (2003). This N plan is recommended as best practice from a cost- efficient and environmental point of view for all farms spreading organic or inorganic inputs onto land, and involves a Manure Management Plan on livestock farms.

4.3. Manure Management Plan (BMP-9)

All livestock farms should have a Manure Management Plan (also known as a Farm Waste Management Plan, FWMP). Farms at which slurry is produced are subject to the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) (Scotland) Regulations 2003 (“the SSAFO Regulations”). For new, substantially enlarged or substantially reconstructed slurry storage systems, the Regulations require the provision of six months storage capacity for the farm as a whole. SEPA may accept a lesser period of storage but only where it can be demonstrated by a FWMP that this will not cause harm to the environment or lead to a significant risk of pollution of the water environment.

The 4 Point Plan (SEERAD *et al.*, 2002) is aimed at livestock farmers and provides guidance on preparing a FWMP: (1) minimising dirty water around the steading, (2) better nutrient use, (3) risk assessment for manures and (4) managing water margins. Plans will assess manure and dirty water volumes, storage conditions, steading discharges and clean water contamination. A Risk

Assessment for Manure and Slurry (RAMS) is part of the FWMP. This involves an examination and soil survey of each field in order to identify the suitability for spreading organic manures. Risk categories for manure spreading based on soil, land, gradient, farming and climatic factors will be identified and mapped according to the following categories:

- (1) No spreading of manure at any time;
- (2) High risk;
- (3) Moderate risk; and
- (4) Low risk.

No spreading areas include

- All land within 10 metres of a watercourse or within 50 metres of a spring well or borehole.
- Steeply sloping land (minimum gradient 11-15°, depending on soil, land, water and climatic factors).
- Rough grazing land.

High risk areas include

- Slopes with a gradient between 8-11° (or 15° depending on soil, land, water and climatic factors), poorly drained, waterlogged or severely compacted soils.
- Fields with drainage inserted in previous 12 months.
- Fields likely to flood annually.
- Sandy/shallow soils over gravel or fissured rock.

Moderate risk areas include

Slopes with a gradient between 4 to 7°

- Imperfectly drained or saturated land
- Land sloping towards watercourses.

Low risk areas are

- Remaining areas with gradients less than 3° and no artificial drainage.

Advisers and consultants should be familiar with The 4 Point Plan before designing a train of BMPs to reduce the potential risk of phosphorus, nitrate and FIO contamination from livestock farms to watercourses. Maps and appropriate elements of a FWMP are given in the general arable farm and dairy farm Case Studies.

A nutrient budget for P and an NVZ fertiliser and manure plan for the farm will be necessary to produce a comprehensive manure and nutrient management plan.

4.4. Soil Erosion and Sediment Control (BMP-22)

Both water and wind can cause erosion of soils and subsequent pollution to the receiving environment. The mechanisms and control of each are quite different and must be treated separately.

4.4.1. Water erosion

Water erosion occurs when the energy dissipated when falling raindrops hit the soil surface detaches individual soil particles from the normally aggregated soil surface. These detached particles may then be subject to erosion. However, for erosion to occur, there must be surface run off of water to transport the detached particles from their initial position. This surface run off, that

is water flowing over the soil surface, can occur when the intensity of the rainfall exceeds the infiltration capacity of the soil or when, in prolonged rainfall events, the whole soil profile above a slowly permeable horizon becomes saturated with water. For erosion to occur, both mechanisms must operate: there must be a supply of detached particles to be eroded and there must be surface run off to provide a transport mechanism for those particles.

Erosion control strategies may either focus on the detachment mechanism or the transport mechanism. Examples of strategies to reduce soil detachment include leaving a cover of crop residues to break the force of the raindrops or increasing soil organic matter content to increase the stability of the soil aggregates and their ability to withstand raindrop impact. Example of strategies to reduce the transport mechanism include prevention or removal of soil capping or compacted layers to increase rain infiltration, the adoption of coarser seedbeds to increase infiltration capacity or the installation of underdrainage to reduce the likelihood of the soil profile becoming saturated.

Once surface run off occurs, the water flowing over the soil surface may itself become a mechanism of soil detachment. To combat this, erosion control strategies such as diversion terraces, contour cultivations or strip cropping are aimed at reducing the volume or the velocity of water flowing over the soil surface. Other strategies such as buffer strips may aim to encourage sedimentation of eroded soil in places where it will do little harm.

4.4.2. Wind erosion

Wind erosion occurs when detached soil particles are blown into the air and then strike and disrupt other soil aggregates producing more detached soil particles. This process known as saltation can result in very large amounts of soil being removed from fields.

Strategies to prevent wind erosion also aim at disrupting either the detachment mechanism or the transport mechanism. Examples of strategies aimed at reducing soil detachment include again the use of crop residue cover to protect the soil surface and the use of soil stabilisers to increase aggregate stability. Examples of strategies aimed at disrupting the transport mechanism include the use of shelter belts to reduce wind velocity at the soil surface.

4.4.3. Riverbank erosion

Riverbanks that are eroding can become steep and undercut, leading to further severe erosion losses. Once the causes, scale and seriousness of the problem have been determined, the choice is then whether to leave the bank to reach its own natural state, or to take some type of remedial action. If remedial action is decided choice of BMPs will depend on the physical characteristics of the river and surrounding land. Fuller details of the methods most commonly used for bank erosion control are described and illustrated in the Farming and Watercourse Management Handbook (2000).

4.5. Grazing Management (BMP-50)

Compliance with Good Agricultural and Environmental Condition (Scottish Executive, 2004) states that in order to protect the land against soil erosion, land should not become badly trampled or poached by livestock. If this occurs stock should be removed until the land has recovered or remedial action has been taken. On peat soils this action will need to be taken earlier than on other soils due to the fragile nature and increased susceptibility of the soil to erosion. Any problems should be rectified by the next growing season after the period that the problem has occurred. When supplementary feeding outdoors, it will often be preferable to rotate feeding sites and make sure feeding rings are suitably positioned i.e. well away from watercourses and not on ground sloping towards a watercourse. Sacrificial feeding areas may be more desirable on improved

grassland/arable land providing the risk of soil erosion is very low. Grazed forage cropped fields that have been poached should be ploughed or sown as ground conditions allow.

Grazing right up to the edge of rivers, burns and ditches without leaving any kind of margin brings with it various problems. Guidance on solutions to the problems of grazing beside rivers is given in the Farming and Watercourse Management Handbook (2000).

4.6. Irrigation Management (BMP-46)

Under the WFD and resulting WEWS regulations, SEPA will be given controls from 2005 onwards to regulate abstraction and impoundment activities. This will include abstraction from surface and groundwater and will cover all existing and new activities. Under the new regulatory regime farmers along with all other water users will be required to illustrate an efficient and effective use of water. Scheduling will therefore become an essential part of their water resource management routine.

Groves and Stansfield (1996) have reviewed the uses and techniques of irrigation scheduling, and Aitken *et al.* (2004) have listed the following measures to reduce water use at times when rivers are already low:

- Use stored water where possible.
- Irrigate in the evening or early morning.
- Locate rain-guns so as to minimise wastage of water that misses target crops.
- Match application rate and droplet size to soil and crop type.
- Use soil moisture monitoring equipment and/or balance sheet scheduling and follow specific crop guidelines to avoid over-irrigating, capping of the soil surface and consequent wasted water, risk of run-off and soil erosion.
- Co-operate with other farmers in same catchment to avoid over abstraction perhaps by drawing up a rota of irrigation times with neighbours.

Consider the needs of wildlife that depend on the river and associated habitat in the river.

4.7. Crop Protection Management Plan

A Crop Protection Management Plan (CPMP) has been devised by the UK's farming unions. It is part of their contribution to the 'Voluntary Initiative' (www.voluntaryinitiative.org.uk) a programme of measures, agreed by Government, to minimise the environmental impacts of pesticides. Advisers and consultants should be familiar with CPMP when selecting BMPs to reduce diffuse pollution by pesticides.

Mixing and filling are crucial operations since it is then that most spills and splashes of concentrate are likely to occur. Advice given in the 'Voluntary Initiative' include:

- Avoid filling sprayers in areas anywhere near drains where drainage water could contaminate rivers, streams or ditches. Protect drains if your only option is to fill the sprayer close by, for example by impermeable kerbing or bunding;
- If possible, set aside a special area for mixing where spills cannot enter watercourses or drains;
- Fill the sprayer on an area of grass and soil that is not vulnerable to groundwater pollution and strengthen with 4-10cm of medium-sized gravel, hardcore road planings to take frequent traffic, rather than on concrete. The area must not be underlain by drains.

Consideration should be given to constructing some type of biobed. These are specially constructed areas where sprayers may be filled and where any spillage will be adsorbed and degraded by an organic matter rich substrate. Further information and design guidelines are available at www.voluntaryinitiative.org.uk.

5. Steading BMPs

5.1 Introduction

Steading BMPs are aimed to reduce pollutant inputs by interception either from roofs or farmyards, and to intercept the pollutants in grass swales, ponds, or biobeds. Normally a sketch plan of the steading will be made as part of the diffuse pollution audit. This will mark the main features of the steading including the position of drains and open watercourses. The 4 Point Plan (SEERAD *et al.*, 2002) gives detailed guidance on minimising dirty water around the steading. General guidance on implementation of steading BMPs is given below, while detailed descriptions on individual BMP sheets BMP-11, 72, 74, 75 and 106 are given in the "Handbook of BMPs".

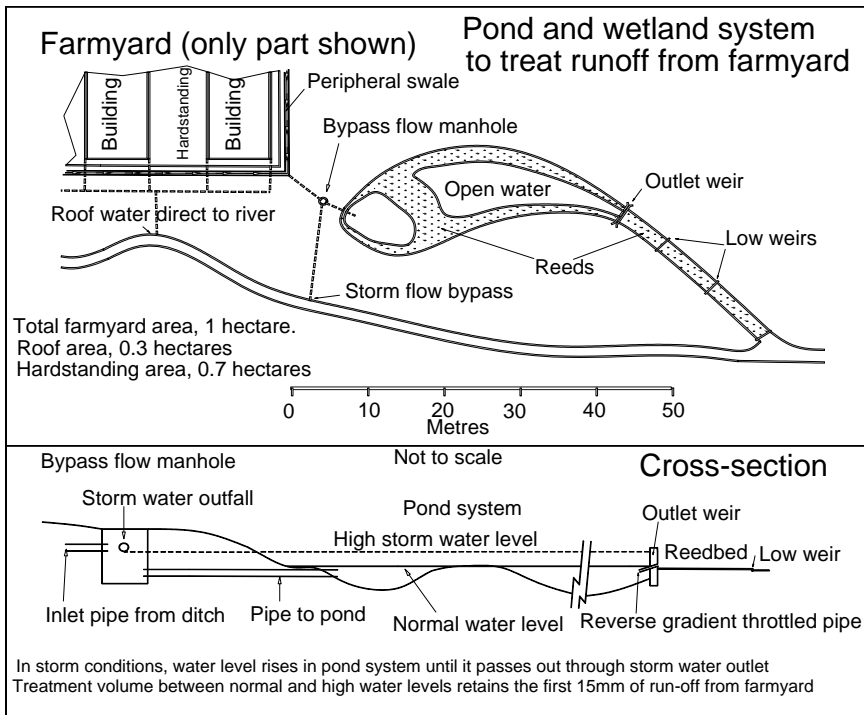
5.2 Roof run-off interception (BMP-11)

As far as possible, clean runoff water, such as water from roofs, should be kept separate from runoff from potentially dirty surfaces. Where possible, dirty runoff water should be minimised by for example roofing feed passages to which housed stock has access. The clean water may be led to drains or watercourses while all slurry should be led to the slurry store (SSAFO Regs, 2001). Subsequent runoff from the steading may be taken to a farm wetland system (see below).

5.3 Farm pond or wetland system (BMP-74)

Decisions must be made about routing of potentially dirty water in compliance with SSAFO Regs (2001). Contaminated water must be led to the slurry store or a similar tank. However, most steadings have surfaces that are only lightly or occasionally contaminated. If all the rainwater runoff from such surfaces is led to the slurry store, the result will be large volumes of dilute slurry to be spread that may present a greater pollution threat. It may be feasible to install a pond/wetland treatment system to deal with the lightly contaminated water. The publication "Guidance on good practice in the management and creation of small waterbodies in Scotland" (SEPA, 2000) should be consulted, as whether such a system is required needs careful consideration. A possible design is shown in Figure 1.

Figure 1. Design for a pond and wetland system to treat runoff from farmyard.



The proximity of the steading to surface water or to drains leading to surface water is an important consideration. If the steading is remote from surface water and runoff simply infiltrates into surrounding land, no system should be installed which provides a direct link to water, even if the runoff is treated en route.

Some stock farms which house cattle in straw based courts and where cattle movements to and from the courts occur only twice each year do not usually present sufficient risk to merit any system. However, on many farms where stock movements are more frequent and on arable farms with large concrete areas with frequent movements of tractors and other machinery and the potential for spillages of fertiliser and other chemicals, pond/wetland systems are often desirable. The same system might also be beneficially used to treat septic tank effluent from the farmhouse at little or no extra cost.

5.4 Constructed wetlands (reedbeds) (BMP-75)

“Constructed wetlands” is a collective term that describes many forms of natural treatment systems for domestic, agricultural, industrial effluents and stormwater. These systems utilise natural processes found in aquatic ecosystems to break down and remove pollutants. The main variation in constructed wetlands is the level of the effluent within the wetland. Treatment ponds can have over a metre depth of effluent, surface flow wetlands will have a few centimetres and subsurface wetlands have an effluent level that coincides with the surface of the growing medium. These subsurface flow wetland systems can be designed for vertical downward flow or horizontal flow. The growing medium will vary, with some systems using soil and others gravel. Re-cycled materials such as burnt oil shale, shells and furnace bottom ash have also been used.

Hayward (2004) has written a SAC technical note on the most common constructed wetland forms used in Scotland. These are the horizontal sub-surface reedbed and the vertical flow reedbed. Pond/wetland treatment systems for steadings run-off were proposed for the general arable farm, dairy farm, arable farm with vegetable production, and the upland stock farm (see Case Studies, section 9). Consultants and advisers should consult Hayward (2004) in order to compare the merits and potential drawbacks of both horizontal and vertical reedbeds and to obtain guidance on their maintenance. Further information on all aspects of pond and wetlands creation can be found in Williams *et al.* (1999), SEPA (2000) and SEPA's Pollution Prevention Guidance Note 4 (www.sepa.org.uk/pdf/guidance/ppg/ppg04.pdf).

5.5 Grass swales (BMP-72)

Hayward and Sharp (2003) have produced guidelines for design and construction of grass swales. They were produced for farms covered by IPPC. Swales are linear depressions formed in the ground to receive runoff from steadings and farm roads and slowly move water to a discharge point. Unlike ditches, they are normally dry except in wet weather and are grassed. Side and longitudinal slopes are gentle. The slow movement of water along the swale, aided by grass and check dams, encourages deposition of solids washed off the hard standing, and helps to remove nutrients such as phosphorus. Swales were proposed for the dairy farm, arable farm with vegetable production, and the upland stock farm (see Case Studies, section 10).

Benefits of using swales are:

- Improves water quality.
- Cheaper to construct than piped systems.
- Can be incorporated into the landscape.
- Low maintenance.
- Visible operation.

The longer the swale is the better. A long swale allows plenty of time for settlement of solids contained in the runoff. Swales of more than 70m in length give good, consistent performance. Swales should have gentle curves and no sharp corners. A swale that curves backwards and forwards with a shallow gradient is better than a swale that is built directly down slope. Shallow swales with no permanent water have better chance of establishing a grass sward.

Location of the swale will depend on the layout of the site and the amount of space available, but the swale would usually run either parallel with or at 90° to the houses, with the hard-standing draining towards the swale. Outflow points into the swale should be capable of being stopped with a drain blocker so heavily contaminated runoff, such as may occur when cleaning out, can be diverted to waste effluent tanks. Larger farms may need more than one swale; a second swale could possibly be located between sheds. Roof water can be directed to the swale via surface drains or via smaller swales.

Check dams are small dams constructed across a swale. The check dam is made from graded broken stone. Run-off will pond behind the dam allowing sediment to settle out. As the check dam is made of stone, it will allow the ponded water to discharge slowly towards the outlet. This improves the efficiency of the swale.

5.6 Good practice in sheep dipping (BMP-106)

The Groundwater Regulations (1998) require that certain listed substances, including sheep dips, do not enter, or do not cause pollution, of groundwater. Dip disposal must be authorised by SEPA to satisfy the requirements of the Regulations. Ensure sites for waste dip disposal:

- are well-vegetated, and flat or gently-sloping, so as to prevent either surface run-off or 'pooling' of the waste dip on the disposal area;
- are more than 10m from a watercourse and more than 50m from any spring, well or borehole;
- are more than 500m from any borehole, or 500m upslope of any spring or well, used for drinking water supply;
- do not have saturated, waterlogged, cracked or frozen soil (to a depth of more than 50 millimetres);
- are freely or moderately drained; and
- have deep loamy or peaty soils.

After dipping, sheep should be allowed to drain in a drip pen for at least 10 minutes to allow surplus dip to drain completely back to the dipper. Once sheep have left the drip pen, subsequent holding areas and their return route to grazing should be chosen such that there is no contact with watercourses and a minimum of 50 metres distance from any spring, well or borehole used as a drinking water supply. Waterlogged ground and hard surfaces, such as metalled roads, should also be avoided.

Further advice on practices that should be followed to minimise pollution from waste sheep dip disposal is given in Stephen (1998) and the PEPFAA Code.

6. In-Field BMPs

6.1 Introduction

In-Field BMPs are listed in the "Handbook of BMPs" in order of their point of intervention in the run-off / erosion process as follows:

- a) BMPs that aim to reduce the amount of a potential pollutant added to the land;
- b) BMPs that aim to reduce the amount of particles that are dislodged from the soil surface;
- c) BMPs that reduce the amount of particles transported from their source to the river;
- d) BMPs that delay the run-off time and reduce the peak flow of run-off; and
- e) BMPs to trap pollutants carried in run-off before it reaches the river.

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General guidance on implementation of in-field BMPs is given below, while detailed descriptions on individual BMP sheets are given in the "Handbook of BMPs".

6.2 Use of soil P analyses to indicate over fertilisation (BMP-1)

Once soil P levels rise sufficiently, rates of loss of P by leaching and other pathways may increase markedly. It is therefore undesirable that soil levels be above those required for the land use in question.

The following recommended soil P levels may be used as a guide (adapted from Dyson, 1992), and are expressed in terms of SAC's soil P extraction:

- Land in improved grassland: no need to be higher than the middle of moderate category, (9mg/l).
- Land growing combinable crops: no need to be higher than the upper part of moderate category, (13mg/l).
- Land growing potatoes and many field vegetables: no need to be higher than the lower part of high category, (20 mg/l).

Different soil laboratories may use different methods of extraction of P from soil and results from different laboratories frequently cannot be directly compared. Withers and Sinclair (200) should be consulted for guidance on sampling soil and planning fertiliser policies.

6.3 Account taken of soil-derived nitrogen (BMP-94)

Adoption of nitrogen fertiliser recommendations from Sinclair (2002) will reduce the risk of applying more fertiliser than the crop needs and will minimise losses of N to the environment. In order to assess the fertiliser N requirement for each crop in each field account must be taken of soil-derived nitrogen. In mineral soils of low organic matter content, the amount of available N supplied by residues is relatively small, whereas in humose and peaty sites low N malting barley is not encouraged as N release occurs late in the season and ends up in the grain.

Nitrogen residues from soil reserves have been arranged into six Groups for Scottish conditions (Sinclair 2002). These Groups are numbered 1 to 6 in ascending order of residual available N in the soil depending on the previous crop or grass/clover management. Residual available N in the soil following harvest is contained in crop debris and organic matter left following the crop's growth, and will vary depending on the crop type grown. Residues following cereals are generally lower than those following break crops. The management and performance of the previous crop can have a significant effect on the actual level of N residues. Residues are expected to be lower in a high yielding season or where N application has been less than normal, but may be higher than average if the crop has performed badly due to problems such as disease or drought. In tables of N requirements it is assumed that all previous crops have been managed well and that previous N use has been close to the recommended rate. Also, N fertiliser and manure use in the last 2 years on grassland, and grazing management during the months immediately prior to ploughing out grassland, will have a significant effect on the level of N residues. Vinten *et al.* (2002) showed that restricted grazing before ploughing out of grass leys is an effective way of reducing nitrate leaching.

6.4 N application rate based on likely crop uptake (BMP-92)

A revised fertiliser recommendation system for N under Scottish conditions has been developed (Sinclair, 2002). It is based on crop response trials, modified by previous crop and grass/clover management, N mineralised from soil organic matter and recent crop debris, ploughing date, sowing date for spring cereals, N lost by overwinter leaching and manuring history. As an example, N recommendations for spring barley grown for animal feed or high N malting are given in the following table:

Spring barley (FEED or HIGH N MALTING): N (kg/ha)

N-residue Group	1	2	3	4	5	6
Sands and shallow soils	150	140	130	110	80-50	40-0
Sandy loams and other mineral soils	130	120	110	90	60-30	20-0
Humose soils	80	70	60	40	10-0	0
Peaty soils	50	40	30	10	0	0

Adjustments:

Undersown crop -25 -25 -25 -25 -25 -25

Deduct N from residues of manures

Delayed sowing –

Reduce by 1.5 kg/ha/day for each day of delay after your optimum sowing period

6.5 Timing of fertiliser applications (BMP-3/4)

Autumn nitrogen is NOT generally recommended as profitable responses are not normally attained and the practice will increase N losses to watercourses. Responses to autumn N have been recorded on sites with sandy soils of high pH and low manganese content. There is also a possible N requirement in some winter barley that has been direct drilled or established following minimum cultivation (Sinclair, 2002).

Chemical nitrogen fertiliser must not be applied to land in the Moray, Aberdeenshire, Banff and Buchan NVZ between

- 15 September and 20 February in the case of grassland; and
- 1 September and 20 February in the case of other land unless there is a specific crop requirement during that time.

In the other NVZs in Scotland the Spring date is 15 February in order to take account of expected earlier spring growth.

In all NVZs fertiliser must not be applied to any land if

- the soil is water logged
- the land is flooded
- the soil has been frozen for 12 hours or longer in the preceding 24 hours; or the land is covered with snow.

These conditions also apply in the PEPFAA Code. For further information on measures in NVZs advisers should consult the Scottish Executive (2003).

6.6 Spreading manures and slurries in appropriate weather conditions and incorporation of manures (BMP-114/24)

The PEPFAA Code gives guidance on spreading manures and slurry and environmental factors e.g. they should not be applied to any land if

- the soil is water logged
- the land is flooded
- the soil has been frozen for 12 hours or longer in the preceding 24 hours; or the land is covered with snow.

Organic manure should not be applied to any land less than 10m from a watercourse. This includes rivers and loch and any temporarily dry ditches. To help protect the quality of groundwater, organic manures should not be applied within 50m of a spring, well or borehole that supplies water for human consumption, or which is to be used in farm dairies.

In NVZs in Scotland the above guidance is mandatory. Also, in NVZs organic manure in the form of slurry, poultry manure or liquid digested sewage sludge must not be applied to any land that has a sandy, or shallow soil

- between 1 October and 1 November in any year where the land is in grass or is to be sown with an autumn sown crop;

- between 1 August and 1 November in any year in any other case.

“Sandy” in relation to soil means sandy, sandy loams and loamy sand textured soils (a) in the soil layer up to 40cm deep; and (b) in the soil layer 40cm deep and up to 80cm deep. “Shallow” in relation to soil means less than 40cm deep.

The amount of N available to the crop following the application of manure depends on the type of manure, method of application, soil type and month of application (Chambers *et al.* 1999; Rees & Castle 2002; Sinclair 2002). Incorporation of slurry by injection directly into the soil or by ploughing within 6 hours after surface-spreading reduces the risk of surface run-off and minimises ammonia losses. Cultivation using discs or tines is likely to be less effective in minimising ammonia losses. Dilution of slurries is known to reduce ammonia losses but dilution of slurry is likely to increase other problems associated with slurry use. Injection is a good method of reducing ammonia emissions but is likely to increase problems of losses of nutrients and pathogens to piped underdrainage. Application by trailing hose in a growing crop can reduce ammonia emissions by 30-40% compared with surface broadcasting, while use of trailing shoes or open-slot injection can reduce emissions by 70% (Laws *et al.*, 2004). Weather conditions are also a factor with cool still days being best. Application during or just prior to rainfall also reduces emissions but this would be highly undesirable on many soils, because of the increased risk of pollution of surface water. The slow infiltration rate characteristic of many Scottish till soils increases the risk of ammonia losses significantly. Injection should be avoided into the backfill or infill over drainage systems, into the subsoil below root depth, or into very light gravel soils. The injector should be worked across the slope, rather than up and down.

When farmyard manure is spread, ammonia emissions can be reduced by incorporating the manure as soon as possible. The problem is worst in summer when volatilisation is likely to be rapid in the warm conditions and losses high unless the manure is incorporated at once, with the plough more or less following the dung spreader. During winter and spring if farmyard manure is incorporated within 24 hours a significant reduction in ammonia emissions and an increase in N available for spring growth can be expected (Sinclair, 2002).

6.7 Conservation tillage (BMP-35)

Conservation tillage provides a means of reducing erosion associated with soil disturbance by reducing the intensity and frequency of cultivation. Erosion has been identified as one of the main contributors by agriculture to the diffuse pollution of fresh waters by phosphorus (D'Arcy *et al.*, 1996). In selecting and siting BMPs to minimise P losses it should be remembered that in the majority of soils, losses of P are most likely to occur through the transport of P associated with colloidal clay or organic matter in both surface run-off and in drainage. These losses are not strongly related to P inputs or the P budget for the system (Edwards and Withers, 1998) but are strongly related to the movement of sediments. Heathwaite *et al.* (1998) showed that greater quantities of P were lost in surface run-off from grassland receiving soluble P fertiliser than from farmyard manure or slurry treatments. Leaching of dissolved P will only occur on soils with high P concentrations, likely to be the result of long-term over fertilisation and/or excessive applications of animal manures where the accumulation of P exceeds the soils sorption capacity (Haygarth and Jarvis, 1999). P surpluses on individual farms will have been highlighted as part of the Nutrient Management Plan (section 4.2).

Ball and Dickson (1998) have described the erosion mechanism, the areas where erosion may give a P pollution hazard, the advantages and disadvantages of non-ploughing tillage techniques that form the core of conservation tillage and recommended modifications of cropping and tillage that could reduce soil and particulate P loss. Ball and Bingham (2003) have identified opportunities for use of minimum tillage and direct drilling in Scotland and made suggestions for their successful

application with minimum risk. Drier and more stable structured soils are best suited to minimum tillage. Winter crops have been more favourable for minimum tillage than spring because seedbed quality is less important and because the faster work rate is more relevant than for spring crops. The most suitable crops are where quick establishment is vital and weeds are readily controlled: winter wheat after winter oilseed rape; winter oilseed rape after winter barley; and winter wheat after peas. Winter wheat after potatoes is also suitable where the land is loose, weed free and not compacted or rutted by wheeling during the potato harvest. Consultants and advisers should consult Ball and Bingham (2003) for further information.

6.8 Ditch Management (BMP-69)

Existing field drainage systems should be maintained including clearing ditches, unless environmental gain is to be achieved by not maintaining field drainage systems. In areas prone to flooding risk good ditch management is essential. Advisers and consultants must ensure that selection and siting of this BMP complies with the Scottish Executive guidelines. Key points in ditch management described in the Farming and Watercourse Management Handbook (2000) include maintaining ditches on a rotational basis leaving 30-50% of vegetation undisturbed, working short sections on alternate banks to minimise damage, maintaining continuity and leaving undisturbed areas as a source for re-colonisation. These key points are particularly important where minimising P loss to watercourses is a priority.

6.9 Accurate pesticide application (BMP-100)

Diffuse pollution involving pesticides and veterinary medicines is most likely to occur in sheep farming areas or areas with a high proportion of arable farms growing field vegetables. Land drained by small watercourses, where most of the catchment lies within agricultural land, tend to be most severely impacted by pesticide pollution. The PEPFAA Code provides guidance to farmers and growers to ensure the safe use of pesticides so as to protect the environment and allow efficient farming activity.

In arable farming areas, in particular, pesticides can contribute to diffuse pollution via field run-off, spray drift and accidental spillages. However, pesticide pollution may occur through inappropriate handling at any stage of use - during storage, mixing, application, or from subsequent disposal of the dilute pesticide washings or the used containers. Field boundaries are a sensitive habitat as pesticide drift into hedges or ditches will reduce their value as wildlife refuges e.g. for bullfinch, brown hare and linnet. Any wetter habitats such as marshy grassland and rush pasture are also very sensitive to pesticide and herbicide drift. When spraying next to a watercourse, low drift nozzles are advised to prevent contamination. In addition to the information on the product label, help with selection of nozzle type is available on a Home Grown Cereals Authority (HGCA) chart, in CPA leaflets and British Crop Protection Council (BCPC) Handbooks.

Crop Protection Management Plans (section 4.7) will set clear management objectives and identify specific issues that need to be addressed in reducing the adverse environmental impact of pesticides use. All elements of the safe use of pesticides are described in the Defra/HSE Code of Practice for the Safe Use of Pesticides on Farms and Holdings (the "Green Code").

6.10 Proper disposal of excess chemical and tank washings (BMP-108)

Whenever possible sprayers should be washed and rinsed out in the field where the pesticide has been used using the minimum amount of water necessary and ensuring that the maximum dose rate is not exceeded. If the sprayer is washed out elsewhere and the resulting washings cannot be used on the treated crop, these washings should be collected for disposal under an authorisation issued by SEPA. The washing facilities provided must be designed to ensure that back siphoning of pesticides into the water supply cannot occur. Non-return valves should be fitted to any taps connected to spray equipment. Such activities will produce a relatively large volume of water contaminated at low concentration with pesticide. If suitable, the contaminated water may be used later for making a further batch of the same dilute pesticide. Protective clothing involved in the operation should be cleaned, washed and rinsed within the area used for cleaning the sprayer.

7. Riparian BMPs

7.1 Buffer Zones

9.3.1 Introduction

Watercourses will have been assessed during the Diffuse Pollution Audit to determine buffer zone and fencing needs to protect the water from livestock. Buffer zones or strips are a useful measure for potentially reducing the impact of a wide range of diffuse pollutants on watercourses, including soil, phosphate, nitrate, pesticides and, in the case of fenced buffer strips, faecal contamination by livestock. Buffer strips act in a different way for each pollutant and this should be taken into account when considering the width of the strip and the management of its vegetation. Buffer strips are described in the Handbook of BMPs that reduce specific dissolved pollutants (**BMP-80**), reduce runoff speed and trap solids (**BMP-79**), and keep agricultural machinery operations away from watercourses to reduce the risk of direct input of a pollutant (**BMP-78**). It is also important to identify the location of field drains relative to proposed buffer strips. There is considerable potential for using buffer strips to enhance farmland biodiversity by creating habitats for invertebrates, small mammals and farmland birds. Buffer zones and fenced areas were proposed for the general arable farm, dairy farm, arable farm with vegetable production, mixed stock and arable farm and the upland stock farm (see Case Studies, section 10).

7.1.2 Buffer strip width

At the simplest level, buffer strips are effective against diffuse pollutants by moving the source (agricultural land) away from the receptor (watercourses), and in the case of pesticides this is the principal way in which they work. The vegetation in buffer strips can also physically trap pollutants such as soil particles (and phosphate) and absorb nitrates through their roots.

The effectiveness of all of these mechanisms is likely to be enhanced by increasing the width of the buffer strip, and so the general guidance should be to make buffer strips as wide as possible. In practice however, the width of buffer strips is likely to be a compromise determined by a number of other factors.

The guidance in the PEPFAA code, NVZ regulations and LERAPs will often be a starting point in determining buffer strip widths. For pesticides, LERAPs must be carried out when spraying closer than 5 metres from a watercourse, so a 5-metre buffer strip will avoid the need for this paperwork. Manures and slurry should not be applied closer than 10 metres to a watercourse in an NVZ, so in this situation a 10-metre buffer strip may be favoured.

In most cases, farmers will be looking to use agri-environment measures or set-aside to offset the cost of buffer strips, so the regulations relating to these schemes are an important factor. Under the Rural Stewardship Scheme, water margins must be between 6 metres and 12 metre in width, arable grass margins must be between 1.5 metres and 6 metres in width. Set-aside strips must normally be at least 20 metres in width, but can be reduced to 6 metres in width if they are next to a watercourse.

If the vegetation in the buffer strip is being established by sowing seed (see below), then the width of the seed drill is likely to be an important factor. If a 3-metre drill is used to sow grass, then a 6-metre or 12-metre buffer strip is likely to be preferable to a 5-metre or 10-metre strip.

Field topography is a major consideration. Watercourses at the foot of steep slopes that are prone to erosion or run-off should have wider buffer strips than watercourses in flat fields. A particular problem that is often encountered when establishing buffer strips is where a steep slope has a short, flat run-out at the bottom, between the slope and the burn. If this flat area is converted into a buffer strip, and particularly if it is fenced, then it can create problems for the farmer having to turn machinery on the steep slope. In these situations the farmer must decide whether to reduce the buffer strip or increase it to take in the whole slope. Such decisions are likely to depend on the perceived value of the land on the slope, but set-aside may be an acceptable option for such slopes.

Buffer strips are unlikely to be effective in controlling suspended solids from eroding soils where the topography concentrates run-off. In-field erosion control measures should be applied in these situations.

7.1.3 Buffer strip management

As well as moving agricultural activity away from watercourses, buffer strips can intercept certain pollutants such as soil, phosphates and nitrates. The effectiveness with which this is done will depend on the way the strip is managed as well as its width.

Vigorous growth of grass or tall-herb vegetation is likely to be the most effective vegetation. Although such vegetation will often develop by natural regeneration on bare ground, quicker establishment and buffer strip effectiveness may be brought about by sowing a suitable seed mix (and may be required under certain agri-environment options).

Development of scrub or woodland vegetation on a narrow buffer strip may be detrimental if it shades out ground layer vegetation. However, there may be significant biodiversity and landscape benefits from allowing limited tree regeneration (for example clumps of native species such as Alder and Ash) alongside watercourses. In situation where scrub or tree regeneration is not desirable, occasional cutting (every two or three years) may be required.

The effectiveness of buffer strips in absorbing dissolved nitrates is often limited and will be further reduced if field drains pass under the buffer strip directly to the watercourse. In some situations it may be possible to cut field drains on the field side of a buffer strip and allow the drainage water to gradually seep through the buffer strips (**BMP-80**). This will generally only be acceptable to the farmer if the buffer strip is lower than the rest of the field (e.g. at the bottom of a slope).

Fuller details of the methods used for siting fenced areas and buffer strips are described and illustrated in the Farming and Watercourse Management Handbook (2000) and the Handbook of BMPs.

8. Suitable BMP treatment trains for each potential diffuse pollutant

8.1 Introduction

As a general rule it is better to intervene as early as possible in the chain of events (Figure 1). The first choice of BMP is to reduce the input of a pollutant. This may involve reduction from the steading and/or in the field. Information on reducing run-off onto fields from farm tracks (**BMP-60**) is given in the BMP Handbook. In the field the farmer is unlikely to be prepared to reduce inputs to levels that do not match the requirement of the crop, as a cost penalty will result. If a BMP is not possible economically, or if it is not sufficient to reduce diffuse pollution to an acceptable level, then it is better to apply an additional control factor further down the chain. In the field, some practices that reduce the risk from one potential pollutant may increase the risk from another i.e. pollution swapping. For example, incorporating slurry within 6 hours of spreading reduces the gaseous loss of ammonia and risk of surface run-off, but places the soluble N in the slurry at greater risk of leaching. In many situations more than one BMP addressing the same factor may be necessary. A treatment train has been selected for each potential pollutant but many more are possible and need to be addressed on a site-by-site assessment

8.2 Phosphorus (P).

Catchments containing lochs are likely to be phosphorus sensitive. This is particularly the case if the lochs have a low flushing rate or are shallow. In such catchments, low rates of phosphorus pollution are likely to cause significant eutrophication of the loch water.

8.2.1 P PRIORITY: ARABLE FARM

PLANNING

- Nutrient management
- Crop management
- Soil erosion and sediment control plans
- Irrigation management

STEADING:

- Reduce run-off onto fields from farm roadways

IN-FIELD: BMPS TO REDUCE P INPUTS

- Use of soil P analyses to indicate over fertilisation
- Liming of acid soils to utilise existing P reserves
- Precision farming techniques

IN-FIELD: BMPS TO REDUCE PARTICLE DISLODGE MENT

- Avoid too fine seedbeds
- Cover crops
- Crop residue management
- Conservation tillage

IN-FIELD: BMPS TO REDUCE RUN-OFF

- Compaction management

IN-FIELD: BMPS TO INTERCEPT P

- Intercept flow at the bottom of a slope by a grass buffer zone

RIPARIAN/BANKSIDE:

- Bank erosion

8.2.2 P PRIORITY: LIVESTOCK FARM

PLANNING

- Nutrient management
- Manure management
- Grazing management
- Soil erosion and sediment control plans

STEADING:

- Clean/dirty water separation
- Reduce run-off onto fields from farm roadways
- Ponds/wetlands

IN-FIELD: BMPS TO REDUCE P INPUTS

- Use of soil P analyses to indicate over fertilisation
- Liming of acid soils to utilise existing P reserves
- Feed/water trough location
- Location of outdoor pigs to minimise the risk of erosion
- Reduction in the dietary P by livestock

IN-FIELD: BMPS TO REDUCE PARTICLE DISLODGE MENT

- Avoidance of over-grazing

IN-FIELD: BMPS TO REDUCE RUN-OFF

- Compaction management

IN-FIELD: BMPS TO INTERCEPT P

- Intercept flow at the bottom of a slope by a grass buffer zone

RIPARIAN/BANKSIDE:

- Bank erosion

8.3 Nitrate (N₀₃).

Areas designated as Nitrate Vulnerable Zones are by definition, a nitrate priority area where diffuse pollution from nitrate is significant. This is particularly so in the case of catchments of public water supply including boreholes. Areas underlain by unconfined aquifers are also to be regarded as particularly sensitive. Action Programme measures in NVZs in Scotland require that a fertiliser and manure plan to assess N fertiliser requirement for each crop and field is prepared and implemented; that N must not be applied in excess of crop need; and that organic manure applications must not exceed specified N limits (Scottish Executive, 2003). The first BMP to be implemented on NVZ-designated farms is the Nutrient Management Plan for N as described in section 3.1. The full Manure Management Plan (section 3.2) is not mandatory in NVZs, except where an application is

made for a grant towards additional storage for slurry. However, in section 3.3 it is recommended that all livestock farms should have a Manure Management Plan.

8.3.1 N PRIORITY: ARABLE FARM

PLANNING

- Nutrient management
- Crop management
- Irrigation management

STEADING: BMPS TO REDUCE N INPUTS

- Reduce run-off onto fields from farm roadways
- Ponds

IN-FIELD: BMPS TO REDUCE N INPUTS

- N application rate based on likely crop uptake
- Account taken of soil-derived nitrogen
- Timing of fertiliser applications
- Accurate fertiliser spreading

IN-FIELD: BMPS TO INTERCEPT N

- Intercept flow at the bottom of a slope by a grass buffer zone

RIPARIAN/BANKSIDE:

- Wetland restoration
- Artificial reed beds

8.3.2 N PRIORITY: LIVESTOCK FARM

PLANNING

- Nutrient management
- Manure management
- Grazing management

STEADING:

- Reduce run-off onto fields from farm roadways
- Ponds

IN-FIELD: BMPS TO REDUCE N INPUTS

- N application rate based on likely crop uptake
- Account taken of soil-derived nitrogen
- Timing of fertiliser applications
- Feed/water trough location
- Location of outdoor pigs to minimise the risk of erosion
- Spreading manures and slurries in appropriate weather conditions

IN-FIELD: BMPS TO INTERCEPT N

- Intercept flow at the bottom of a slope by a grass buffer zone

RIPARIAN/BANKSIDE:

- Wetland restoration
- Artificial reed beds

8.4 Faecal indicator organisms (FIOs).

Areas draining to designated bathing waters, or other water where people are likely to use in recreation are particularly sensitive to microbiological pollution. Aitken *et al.* (2001) reported on a risk assessment of 117 farms in Scotland and found that risks of discharges of effluents and FIOs into watercourses occurred on over 50% of farms. These mainly arose from the leakage from steadings including middens, poorly designed or mis-managed waste storage facilities, and run-off from self-feed silage aprons, farmyards, cattle courts and cow tracks. Other potential pathways of FIO to watercourses included field diffuse discharges via run-off and field drainage, particularly from areas of poorly managed slurry application and intensive grazing. Diffuse FIO water pollution from agriculture is therefore the cumulative affect of many small steading and field sources over a large area and is hard to quantify and fully control.

8.4.1 FIO PRIORITY: LIVESTOCK FARM

PLANNING

- Nutrient management
- Manure management
- Grazing management

STEADING: BMPs TO REDUCE FIO INPUTS

- Reduce run-off onto fields from farm roadways
- Ponds

STEADING: BMPs TO REDUCE PEAK WATER FLOW

- Roof run-off interception
- Farmyard run-off interception

IN-FIELD: BMPs TO REDUCE FIO INPUTS

- Feed/water trough location
- Location of outdoor pigs to minimise the risk of erosion
- Spreading manures and slurries in appropriate weather conditions
- Incorporation of manures
- Livestock exclusion
- Livestock trails

IN-FIELD: BMPs TO REDUCE PARTICLE DISLODGE MENT

- Access tracks/roads

IN-FIELD: BMPs TO INTERCEPT FIOs

- Intercept flow at the bottom of a slope by a grass buffer zone

- Focus run-off into buffer zones at critical places on a slope

RIPARIAN

- Fence rivers

8.5 Ammonia (NH₃)

The only relevant BMP on arable farms with no livestock concerns the use of urea-based fertilisers. If applied in windy conditions to dry, warm, alkaline soils very significant losses of ammonia may result. Such soils are not particularly prevalent in Scotland. Emissions of ammonia arise from spreading manures and slurries, from grazing livestock and from use of nitrogenous fertilisers based on urea. Emissions from animal housing are most significant and are dealt with under steading issues. Many of the measures that reduce atmospheric pollution by ammonia are likely to increase the risks of water pollution to groundwater.

8.5.1 NH₃ PRIORITY: LIVESTOCK FARM

PLANNING

- Nutrient management
- Manure management
- Grazing management

STEADING: BMPs TO REDUCE NH₃ LOSSES

- Roofing of uncovered silo (only if structure is suitable)

IN-FIELD: BMPs TO REDUCE NH₃ LOSSES

- Timing of fertiliser applications
- Spreading manures and slurries in appropriate weather conditions
- Manure injection
- Incorporation of manures

8.6 Suspended solids (SS).

Salmon, trout and certain other fish require clean gravel with flowing water to spawn successfully. Such gravel beds can become choked with silt from agricultural or forestry runoff seriously damaging the fish. Such waters with significant spawning beds for salmonids and other fish are likely to be particularly sensitive to pollution by suspended solids.

Areas with predominantly arable farming including little rotational grassland, with top soils of a fine sandy loam texture, particularly if the parent material is Old Red Sandstone, and with steep (greater than 7 degrees) gradients are likely to be particularly susceptible to soil erosion. This does not mean erosion will not occur on other catchments. Suspended solids are carriers of P and pesticides and therefore cause further pollution.

8.6.1 SS PRIORITY: ARABLE FARM

PLANNING

- Soil erosion and sediment control plans

IN-FIELD: BMPs TO REDUCE PARTICLE DISLODGEEMENT

- Avoid too fine seedbeds

- Conservation tillage
- Cover crops

IN-FIELD: BMPs TO REDUCE RUN-OFF

- Compaction management
- Contour cultivations
- Contour cropping

IN-FIELD: BMPs TO INTERCEPT SS

- Intercept flow at the bottom of a slope by a grass buffer zone
- Focus run-off into buffer zones at critical places on a slope

RIPARIAN/BANKSIDE: BMPs TO INTERCEPT SS

- Wetland restoration
- Artificial reed beds
- Buffer zones – solids reduction

RIPARIAN: BMPs TO AMELIORATE SS POLLUTION IN-STREAM

- Bank erosion
- Stream bank stabilisation

8.6.2 SS PRIORITY: LIVESTOCK FARM

PLANNING

- Soil erosion and sediment control plans

STEADING: BMPs TO REDUCE SS INPUTS

- Reduce run-off onto fields from farm roadways
- Ponds

STEADING: BMPs TO REDUCE PEAK WATER FLOW

- Farmyard run-off interception

IN-FIELD: BMPs TO REDUCE SS INPUTS

- Feed/water trough location
- Location of outdoor pigs to minimise the risk of erosion
- Location of forage crops

IN-FIELD: BMPs TO REDUCE PARTICLE DISLODGEEMENT

- Avoidance of over-grazing

IN-FIELD: BMPs TO REDUCE RUN-OFF

- Compaction management

IN-FIELD: BMPs TO INTERCEPT SS

- Intercept flow at the bottom of a slope by a grass buffer zone
- Focus run-off into buffer zones at critical places on a slope

RIPARIAN/BANKSIDE: BMPs TO INTERCEPT SS

- Wetland restoration
- Artificial reed beds
- Buffer zones – solids reduction

RIPARIAN: BMPs TO AMELIORATE SS POLLUTION IN-STREAM

- Bank erosion
- Stream bank stabilisation

8.7 Pesticides and veterinary medicines

Diffuse pollution involving pesticides and veterinary medicines is most likely to occur in sheep farming areas or areas with a high proportion of arable farms growing field vegetables. Land drained by small watercourses, where most of the catchment lies within agricultural land, tend to be most severely impacted by pesticide pollution.

4.7.1 PESTICIDE PRIORITY: ARABLE FARM

PLANNING

- Crop management

STEADING: BMPs TO INTERCEPT PESTICIDES

- Use of "Biobeds" while filling sprayer
- Ponds
- Proper disposal of excess chemical and tank washings
- Low volume sprayer washing

IN-FIELD: BMPs TO REDUCE PESTICIDE INPUTS

- Accurate pesticide application
- Targeted pest control techniques
- Integrated pest management
- Precision farming techniques
- Use of anti-drift agents
- Use of spray adjuvants
- Novel seed treatments

IN-FIELD: BMPs TO INTERCEPT PESTICIDES

- Intercept flow at the bottom of a slope by a grass buffer zone

RIPARIAN: BMPs TO INTERCEPT PESTICIDES

- Wetland restoration
- Artificial reed beds
- Buffer zones – dissolved pollutant reduction

9. Habitat Enhancement.

Other factors must be taken into account when selecting BMPs, such as habitat benefits, cost effectiveness, and the likely level of BMP participation across a catchment. A diffuse pollution audit will not normally include a full habitat survey. However, some level of habitat survey is desirable as many possible BMPs that address diffuse pollution issues will also present opportunities for habitat enhancement. A number of such BMPs are proposed in the farm case studies (see section 10), and are described in the following sections.

9.1 Ponds

Ponds created or restored should incorporate the following features to maximise wildlife benefit:

- Do not site ponds where other habitats are likely to be destroyed or adversely affected, e.g. in or adjacent to wetlands which would be drained by the operation;
- Ponds should have a reliable water supply from an off-stream source; and
- Undulating shoreline of variable depth.

If the pond is to be planted, only native plants should be used and invasive plants such as Canadian Pondweed avoided. Shallow areas should be incorporated with dense vegetation to provide cover for amphibians like frogs and toads, and invertebrates such as dragon and damselfly and their larvae. Islands are only useful in large ponds as they should be 4-5m from the shore and surrounded by deep water to give protection to nesting birds from predators. The publication "Guidance on good practice in the management and creation of small waterbodies in Scotland" (SEPA, 2000) should be consulted.

9.2 Hedges

Hedges should not be cut more frequently than every 3 years or less. Cut in January and February after berries and seed have been eaten and before birds start to nest. New hedge planting and gap filling should use a mix of native species such as hawthorn, blackthorn, hazel and dogrose. Extended hedges are allowed to grow wider and taller than normal, by keeping livestock and cultivations back at least 3 metres. The resulting grass/hedge habitat is excellent for species such as grey partridge, providing nesting and feeding ground. Hedges, especially when managed as extended habitats, are important as wildlife corridors. New hedges should be sited to bear this in mind, connecting with other habitats to allow wildlife to move across and around the farm.

9.3 Wetland / wet grassland for waders

Existing wetland should not be drained. Waders prefer an open, tussocky sward for nesting and feeding: grazing is important in wetland management to avoid swamping with dominant species such as soft rush. Some degree of poaching by cattle is encouraged as it opens up feeding opportunities for birds. Grazing from beginning of July is ideal, allowing birds to fledge but not leaving it too long for the rushes and tall grass to grow. When creating a new wetland, small pools and scrapes can be incorporated to retain water. The use of a flexible pipe enables controls over the water level, which can be dropped in late summer to allow cattle grazing to maintain an open, short sward. No fertiliser should be applied to wetland, nor should it be used for supplementary feeding.

9.4 Existing species-rich and unimproved grassland

Grassland that has not been improved supports a range of native grasses and wildflowers that in turn support insects such as butterflies and bees. These grasslands often exist on steep, unploughable slopes. Do not use these areas for siting supplementary feed rings. Do not apply FYM, chemical

fertiliser, herbicides or lime. Grazing should be avoided between April and July. Do not over graze. Sheep are less damaging than cattle to grasslands on slopes.

9.5 Creation of species-rich grassland

This is best suited to soils of low fertility to reduce competition from more competitive species. Ensure that the site chosen does not have existing botanical value. A good seedbed is needed with the elimination of weeds. A suitable seed mix should be obtained from a specialist seed supplier using seeds of Scottish provenance. Grasses should include bents, fescues, crested dogs tail, meadow grass, meadow foxtail. Flowers can include yarrow, common knapweed, ox-eye daisy, meadow buttercup, selfheal. Yellow rattle can be included to repress grasses as it is parasitic on grass and serves to open up the sward, increasing the botanical diversity. Management in the first 3 years should include early cuts in June/July to reduce fertility and prevent grasses swamping the flowers. It is essential to remove the cuttings. In later years the grassland can be cut in July/August and aftermath grazed. FYM, fertilisers or herbicides should not be applied.

9.6 Unharvested crop

These can be maintained for one or two years. Two-year mixes need a biennial such as kale. They are retained through the winter, reducing diffuse pollution and providing a seed source for birds. A range of locations is best – some birds prefer to be in open ground while others prefer to have tree/shrub cover nearby. Overhead-wires that provide safe perching are very much a favoured feature. Seed mixes must comply with RSS rules (if applicable) and should be designed to benefit a range of birds by including components such as kale, oats, rape, mustard, quinoa etc (see also Set-aside Wild Bird Cover in section 9.10).

9.7 Extensive cropping

This RSS option increases the conservation value of arable land in LFAs by encouraging traditional cropping rotations that will provide a cover and a year round food resource for birds and other wildlife. The reduced inputs (restricted to 250kg compound fertiliser/ha) and delayed spring ploughing will reduce diffuse pollution. A rotation could be barley, barley, barley, fodder rape, barley undersown with grass.

9.8 Grass field margin

Field margins may combine a boundary feature such as a hedge, dyke or fence with a strip of permanent natural vegetation, or the margin may just be a grassy strip separating one field from another. They are important wildlife corridors and should link habitats together. A suitable mix of tussocky grass such as cocksfoot and some wild flowers like ox-eye daisy and knapweed, or a cheaper option of red clover should be sown.

9.9 Conservation headland

Choose headlands next to good nesting cover. Avoid headlands infested with difficult weeds (especially cleavers). Conservation headlands are also valuable in the winter if left as stubbles as the weedy stubbles support seed-eating farmland birds such as corn bunting and yellowhammer.

9.10 Set-aside

Wild Bird Cover on set-aside is an excellent food source for birds in winter. Set-aside rules must be followed and a 1 or 2 year mix sown. Wild Bird Cover should be located to complement other features similarly to Unharvested crops (section 7.6). On regenerated set-aside avoid topping when birds may be nesting. If necessary, a derogation can be obtained to delay cutting. Up to 25% of set-aside can be left uncut to benefit wildlife and add diversity to the habitat. 10m buffer strips can be used along watercourses.

9.11 Riparian woodland

This is one of the most effective options for preventing diffuse pollution reaching watercourses as the woodland provides a wide, effective buffer zone. The establishment of riparian woodland receives the highest level of funding under the Scottish Forestry Grant Scheme. Riparian woodland is a Biodiversity Action Plan priority habitat and supports a range of BAP species including otter and improves the habitat for trout and salmon. Minimum width is 25m each side, from the edge of the watercourse. Minimum size is 0.25ha. The riparian zone must adjoin water courses greater than 1m, except where important habitat linkages can be made along a watercourse closer to its source. When planting a new riparian woodland appropriate native species should be used, such as willows, alder, downy birch. Conifers along watercourses should be managed to avoid overshadowing. If possible, felling and re-planting with natives should be considered. Livestock need to be excluded by fencing and an alternative off-stream watering provided.

10. Financial Issues

In **Handbook of BMPs** data on **costs** are recorded as cash values, where they have been reported in the literature. Four components are considered: set up costs; the lifetime of any equipment bought or engineering carried out (or alternatively the frequency of repeating an operation); the running costs and the opportunity costs (for example, the value of the lost crop which could have been grown on a buffer strip). Where savings can be quantified, they should also be included.

In situations where the savings for a BMP are greater than the costs, a farmer cost-benefit analysis is given in **The Handbook of BMPs** (i.e. a cost benefit as seen by the farmer, which does not include the value of benefits or costs which accrue to the general public, for example by an improvement in water quality). Where no clear cost-benefit to the farmer can be identified a cost effectiveness figure may be given, i.e. the cost per unit of pollutant removed. This allows different BMPs to be compared.

The farmer cost-benefit analysis should also include any relevant grants that are available under agri-environment schemes. Examples of BMP options are given in the table below. Government Schemes that could be used to offset the costs of BMPs are also given below. Historically conditions and levels of payments in these Schemes have changed. The adviser needs to be up to speed with any new Scheme.

The main grant scheme available to farmers is the Rural Stewardship Scheme (RSS), Scotland's agri-environmental scheme operated by SEERAD. A wide menu of habitat management and creation options is available, many of which are pertinent to diffuse pollution BMP (see table below). On successful application, the farmer receives annual payments to fund management and capital works for 5 years.

The Forestry Commission offers grants to farmers under the Scottish Forestry Grant Scheme (SFGS). The main option of interest through this scheme in terms of diffuse pollution is Riparian Woodland Planting, grant aided as 90% of standard planting costs. This is the most long-term, effective measure to prevent diffuse pollution reaching watercourses.

Occasionally local grant schemes are available to farmers, such as rivers projects, biodiversity initiatives etc. Advisers should be aware of these before visiting a farm. Local FWAG or SNH offices should be able to offer advise on these.

The use of agri-environment schemes such as the RSS as a means of offsetting the costs of BMPs also offer benefits to the public good in terms of habitat creation for priority species in the UK biodiversity action plan. Grass margins and water margins offer undisturbed habitats for a variety of declining farmland birds such as yellowhammer, reed bunting and corn bunting. Hedge planting also benefits yellowhammers and linnets, while creation of wetland is likely to benefit species such as snipe, water vole, otter and redshank. Spring cropping is of benefit to flagship species such as skylark, lapwing and brown hare.

Table - Rural Stewardship Scheme Management Prescriptions relevant to BMPs

Management Prescription	Description
Water Margin	Uncultivated and ungrazed strip between 6m and 12m in width alongside a watercourse
Grass Margin/ Beetlebank	Grass strip of between 1.5m and 6m in width around the perimeter, or across the middle of arable fields
Conservation Headland	No application of herbicides, insecticides and (for premium payment) nitrogenous fertiliser to the headlands (minimum width 6m) of an arable field
Extended Hedges	Uncultivated and ungrazed strip between 3m and 6m in width adjacent to an established or newly planted hedge.
Planting of hedges	Mix of native species must be planted at a minimum spacing of 6 plants per metre
Creation of Wetland	The site must be managed to ensure that it is saturated with water for a significant proportion of the year and must not be mown or grazed for at least three consecutive months between 15 April and 15 August
Creation of Species-rich grassland	The site must be arable-registered land and must be sown with a mix of native grasses and wild flowers. The site must not be grazed or mown between 15 April and 15 August and must not be fertilised.
Spring Cropping (non-LFA areas only)	Ploughing, cultivations and the spreading of fertiliser may only take place between 28 February and 15 May.

Some situations where the BMP will either not work or have reduced efficiency have been identified in the **Handbook of BMPs**. Generally they are not referenced, having come from

personal communications. However, they should be taken into consideration when assessing the potential usefulness of a BMP in a particular catchment.

The **Handbook of BMPs** also includes an assessment of the likelihood that farmers could be persuaded to implement and maintain a particular BMP, although it is at the moment based on the comments of a small number of people. The availability of compensatory payments (e.g. set-aside, RSS) is likely to be a major factor in encouraging farmers to undertake BMPs.

Selection and siting of BMPs must be consistent with the definition of Good Agricultural and Environmental Condition under the CAP reform (Scottish Executive, 2004).

11. Farm Case Studies

References

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