Please see Annex RN3 for supporting information, and the “Introduction” for Health and Safety considerations and advice on the use of the guidance.

1. **Are the quarry base/overburden contours correct**
   The levels of the prepared overburden base should be such that once the soil profile is restored the landform is as approved in the agreed restoration scheme.

2. **Is low level restoration with perpetual pumping proposed**
   Where the restoration is to be below the surrounding water table level, it will be necessary to safeguard the drainage of the site in perpetuity. The operators will need to address the following matters satisfactorily:
   - lining of the site to limit the ingress of groundwater
   - pumping in perpetuity for the land via a legally enforceable agreement

3. **Is settlement likely to be significant and if so how have the operators allowed for it**
   Settlement is only likely to be significant for sites filled with putrescible waste. Sites filled to good practice standards with inert waste should not be subject to significant settlement. Do the proposals adequately cover:
   - predicted settlement levels and surcharging of waste
   - additional considerations for sites managed as bio-reactors
   - interim restoration
   - differential settlement
   - pre- and post-settlement contours

4. **Are the restoration contours as agreed**
   It is important that the operators restore the site to the agreed landform in order that the restoration and after-use objectives are achieved. The operators should provide:
   - pre- and post-settlement surveys as appropriate
   - where the restored contours are not as agreed, proposals to remedy the situation
   - even slopes without backfalls to aid underdrainage
   - site boundaries that merge appropriately with adjoining land
   - no “dead - end” valley features
   - reasonably shaped/sized enclosures

5. **Are the landform and the design of the landfill gas and leachate control infrastructure compatible**
   The design of the working and restoration schemes should include
consideration of the landform, after-use and landfill gas and leachate controls in a holistic way, such that conflict between differing requirements can be minimised. Do the proposals adequately cover:

a. **capping of the site**

b. **design, location and timing of landfill gas and leachate controls**

c. **interim restoration**

d. **settlement rates**

e. **increased run-off**

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6. **Is the provision of infrastructure as agreed**

Have the operators provided in accordance with the agreed proposals:

a. **surface manholes, inspection chambers and controls for landfill gas and leachate**

b. **appropriate access arrangements for monitoring and maintenance of wellheads etc**

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**COMMENTS**

For more detailed information see:

- The Reclamation of Mineral Workings to Agriculture (DoE 1996)
- Guidance on Good Practice for the Reclamation of Mineral Workings to Agriculture (DoE 1996)
- **Good Practice Guide for Handling Soils** (MAFF April 2000)
- **MPG7 The Reclamation of Mineral Workings** (DoE 1996)
- Low Level Restoration of Sand and Gravel Workings (DoE 1989)
- **Waste Management Paper (WMP) 26B Landfill Design, Construction and Operational Practice** (DoE 1995)
- Landfill Gas and Leachate Control Applied to Arable After-use (MAFF 1998 PR4869)
- Evaluation of Mineral Sites Restored to Agriculture (LRA 2000)

Cross references:

- **AP 5**
- **SW 3**
- **RN 8, 9, 10**
- **AC 3, 9, 10**
1. Are the quarry base/overburden contours correct

In order to achieve the agreed landform, it is essential to prepare the quarry base to the correct levels, such that when the soil profile is restored, the levels are as agreed in the restoration scheme. It is not acceptable to vary the depth of the soil profile because of incorrect base levels, in order to achieve the agreed landform levels. This results in areas of over-deep and shallow soil profiles, which may reduce the agricultural potential of the land, as well as not being a sustainable use of valuable soil resources. Over-deepening of topsoil may lead to anaerobic conditions at the base of the subsoil layer (Evaluation of Mineral Sites Restored to Agriculture (LRA 2000) page 67), whilst shallow soil profiles may increase droughtiness.

2. Is low level restoration with perpetual pumping proposed

Where restoration proposals are to safeguard the long-term agricultural potential of the land, and involve restoring it at a level below the surrounding water table, the restoration must be planned from the very beginning of the design of the schemes of working and restoration (Low Level Restoration of Sand and Gravel Workings (DoE 1989) Chapters 3, 5, 8 and 9). The operators will need to address the following matters satisfactorily:

<table>
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<th>a. lining of the site to limit the ingress of groundwater</th>
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<td>The need to reduce the ingress of groundwater into the site by lining the base and sides. The operators should provide details of their proposals for agreement prepared by appropriately qualified persons to demonstrate that they are sound and practical.</td>
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<th>b. pumping in perpetuity for the land via a legally enforceable agreement</th>
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<td>The restored land will require an underdrainage scheme with a perpetually pumped outfall, as a gravity outfall will not be available. The legal enforceability of perpetual pumping agreements is a complex matter, and qualified legal advice should be sought as appropriate. The sustainability of restorations relying on perpetual pumping may also be called into question.</td>
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3. Is settlement likely to be significant and if so how have the operators allowed for it

<table>
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<th>a. predicted settlement levels and surcharging of waste</th>
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<td>Significant settlement should only occur on sites filled with putrescible waste, where allowances for the settlement that occurs as the waste degrades needs to be made. Significant settlement occurs mostly in the first 5 years following landfilling, and operators typically surcharge the site with waste by 15-20% to achieve the agreed post settlement contours. Recent studies have shown that settlement rates may exceed 20%. Post settlement gradients should be no flatter than 1 in 25 to aid drainage and limit surface ponding of water due to differential settlement. (Waste Management Paper (WMP) 26B Landfill Design, Construction and Operational</td>
</tr>
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</table>
If settlement is found to be significantly different from predictions, this should be highlighted as early as possible, to enable the operators to discuss any implications and amendments with the MPA, EA and agricultural advisers, such as increasing/reducing the depths of waste landfilled, or changes to the landform. It is important to recognise that settlement rates will increase where landfill gas is actively extracted. This may have implications for the landform and after-use of sites where the proposals to extract landfill gas are made after the final landform is agreed or restored.

b. additional considerations for sites managed as bio-reactors
Sites to be managed as bio-reactors for accelerated stabilisation have special design requirements with intensive landfill gas and leachate controls enabling leachate to be re-circulated (see Waste Management Paper (WMP) 26B Landfill Design, Construction and Operational Practice (DoE 1995) Appendix D). The management of these sites may bring advantages such as more rapid stabilisation in terms of settlement and landfill gas production, but disadvantages in terms of rapid settlement and the need for remedial works to the sub-cap irrigation system requiring major site disturbance. These problems may be reduced with interim restoration and careful design, monitoring and liaison between staff involved in engineering, restoration and aftercare (Waste Management Paper (WMP) 26E Landfill Restoration and Post Closure Management Consultation Draft (Environment Agency August 1996) paragraphs 7.37 - 7.45).

c. interim restoration
Proposals may include interim restoration, where the site is capped and up to 50cm of subsoil is spread to protect the cap and support grass growth for a period of up to 5 years. This allows for the worst of the settlement to occur and any necessary remedial works to be carried out before the land is fully restored. Advantages of interim restoration may include higher standards of final restoration, less contamination and damage to soil, and less interference to the land once fully restored. Disadvantages may include the delay of the start of aftercare (Waste Management Paper (WMP) 26E Landfill Restoration and Post Closure Management Consultation Draft (Environment Agency August 1996) paragraphs 7.18-7.25). Where interim restoration is proposed, this should form part of the original design proposals for working and restoring the site.

d. differential settlement
Differential settlement may cause greater problems than general settlement of the whole landform, leading to localised hollows, low points in land drainage pipes, and disruption of landfill gas and leachate control infrastructure. These problems may require the pipework to be excavated and repaired, and the low areas stripped of topsoil and surcharged with subsoil before replacing the topsoil, with obvious consequences to the after-use.

e. pre- and post-settlement contours
Proposals should include details of the pre-settlement contours with appropriate surcharging and post-settlement contours to show the final landform. Generally,
final gradients should be no flatter than 1 in 25 to allow for adequate drainage and to minimise ponding created by local differential settlement (Waste Management Paper (WMP) 26B Landfill Design, Construction and Operational Practice (DoE 1995) paragraph 6.5).

4. Are the restoration contours as agreed

The agreed landform will be designed to meet the restoration and after-use objectives and it is therefore important that it is achieved. The landfill gas and leachate control infrastructure, drainage scheme and after-use are designed on the basis of the agreed landform, and they may not always be easily amended. The operators should provide:

a. **pre- and post-settlement surveys as appropriate**

The operators should undertake pre- and post-settlement surveys where necessary, to confirm that that the landform is as agreed. Where significant settlement is expected, a number of surveys may be required until the majority of the settlement has occurred. BMV land cannot be steeper than 1 in 8 (7 degrees), and subgrade 3b 1 in 5 (11 degrees) (MPG7 The Reclamation of Mineral Workings (DoE 1996) Table 1). For sites filled with putrescible waste, post settlement gradients should be no flatter than 1 in 25 to ensure adequate drainage and minimise surface water ponding in the event of localised differential settlement. The majority of settlement takes place in the first 5 years following landfilling. To take account of settlement, sites are typically surcharged by 15 - 20% (Waste Management Paper (WMP) 26B Landfill Design, Construction and Operational Practice (DoE 1995) paragraphs 6.5, 6.12 and 6.13). Recent studies have shown that settlement rates may exceed 20%. Pre-settlement contours should also be suitable for the agricultural after-use, both to take account of the agricultural requirements at the start of the aftercare period, and also in the event that settlement is significantly less than predicted.

b. **where the restored contours are not as agreed, proposals to remedy the situation**

Where either pre- or post- settlement contours are not as agreed, the operators should provide proposals to remedy the situation. From an agricultural point of view, any proposals will have to be assessed on the basis that, where soil has already been restored, more damage may be caused by re-stripping and replacing it than by leaving the restoration undisturbed. Interim restorations have the advantage in these circumstances as, if surcharging of waste is required, only part of the subsoil layer will need to be stripped and replaced.

c. **even slopes without backfalls to aid underdrainage**

Even slopes facilitate the use of agricultural machinery. Backfalls can lead to difficulties with drainage schemes and also to surface ponding of water.
d. **site boundaries that merge appropriately with adjoining land**
   Sites boundaries should tie in with adjoining land levels to prevent potential problems with ponding of surface water. This is essential where the restored land may in the future form, with adjoining land, part of a larger enclosure.

e. **no “dead-end” valley features**
   Restored landforms should not include valley features forming “dead-ends”, as this may lead to drainage problems and surface water ponding.

f. **reasonably shaped/sized enclosures**
   Modern farm machinery tends to be large and is designed to operate in straight lines as far as possible. Restored field enclosures, particularly where arable crops are to be grown, should therefore be reasonably large (e.g. >8 ha, depending upon the part of the country) and mainly square or rectangular. Hedgerows, particularly where it is proposed that they are allowed to grow tall, should be planted in a north-south orientation to reduce crop shading. However, these requirements represent ideals, and will need to be modified in line with site constraints and landscape requirements.

5. **Are the landform and the design of the landfill gas and leachate control infrastructure compatible**
   
   It is essential for a holistic approach to be taken in the design of the working and restoration of the site, including the design of the landform to take account of a number of objectives including, the after-use and the need for landfill gas and leachate controls. This holistic approach should involve continuing inputs from agricultural specialists and designers of the landfill gas and leachate control infrastructure, together with the EA to ensure that any conflicting interests between the after-use and waste management licence conditions are minimised. Do the operators proposals adequately cover:

   a. **capping of the site**
      This will normally be using clay or a man-made impermeable membrane. If clay has been sourced from the site, has this been achieved without compromising the restoration? For example, has clay that is required for the restored soil profile been used for cell engineering, daily cover or capping?

   b. **design, location and timing of landfill gas and leachate controls**
      The design of these controls will have a very significant impact on the success of an agricultural after-use, particularly where arable cropping is proposed. Where there are surface features such as wellheads, particularly where not arranged in parallel lines, this may significantly restrict an arable after-use, as may having less than 1 metre of clear soil above the crown of any landfill gas or leachate control pipework. Where this is the case it may not be possible to install an underdrainage scheme, which is normally a prerequisite for arable cropping on a capped site. The impacts of landfill gas and leachate control infrastructure on arable after-uses, and the ways
to minimise them is complex, and is covered in detail in Landfill Gas and Leachate Control Applied to Arable After-use (MAFF November 1998 PR4869).

c. interim restoration

Proposals may include interim restoration, where the site is capped and up to 50cm of subsoil is spread to protect the cap and support grass growth for a period of up to 5 years. This allows for the worst of the settlement to occur, and any necessary remedial works to be carried out before the land is fully restored. Advantages of interim restoration may include higher standards of final restoration, less contamination and damage to soil, and less interference to the land once fully restored. Disadvantages may include the delay of the start of aftercare (Waste Management Paper (WMP) 26E Landfill Restoration and Post Closure Management Consultation Draft (Environment Agency August 1996) paragraphs 7.18-7.25).

Where interim restoration is proposed this should form part of the original design proposals for working and restoring the site. Where proposals are to have temporary surface pipework for landfill gas, this will rule out arable after-uses and possibly agriculture altogether, at least until the pipework is installed below ground level. Where it is proposed to drill the gas wells and install pipework once restoration is complete, this may cause significant damage to the soil on site as well as its contamination with waste materials.

d. settlement rates

It is important to recognise that settlement rates will increase where landfill gas is actively extracted. This may have implications for the landform and after-use of sites where the proposals to extract the landfill gas are made after the final landform is agreed or restored. Where remedial works are required to correct differential settlement this should be carried out by stripping topsoil, surcharging the subsoil and then replacing the topsoil.

e. increased run-off

Where sites are capped it is important to understand the drainage requirements of the land. The aim should be for rainfall to percolate down through the soil profile, and not be shed from the soil surface. Where there is no impermeable barrier (i.e. cap) below the soil profile, this water should drain through the soil profile until the water table is reached, which may be several metres below ground level. With a capped site, it is necessary to have a drainage scheme to remove the water from the base of the soil profile above the cap, to prevent the soil from slumping and losing structure in very wet conditions, to enable agricultural machinery to run on the ground, and plant roots to exploit the whole soil profile. Therefore, a capped site may result in more water having to drain from the site via surface ditches etc. compared to before the site was disturbed. It is therefore necessary to consider the ability of the existing ditches/soakaways to cope with this increase in water, as well as any improvements that may be necessary. This may include new ditches, soakaways or balancing ponds.
6. *Is the provision of infrastructure as agreed*

Have the operators provided the following as agreed, including in the correct location:

**a. surface manholes, inspection chambers and controls for landfill gas and leachate**

It is important that the operators have designed, installed and located these items in accordance with the agreed proposals, otherwise they may severely limit the agricultural after-use. The design of these controls will have a very significant impact on the success of an agricultural after-use, particularly where arable cropping is proposed. Where there are surface features such as wellheads, particularly where not arranged in parallel lines, this will in some cases significantly restrict an arable after-use, as may having less than 1 metre of clear soil above the crown of any landfill gas or leachate control pipework. Where this is the case, it may not be possible to install an underdrainage scheme, which is normally a prerequisite for arable cropping on a capped site. The impacts of landfill gas and leachate control infrastructure on arable after-uses and the ways to minimise them is complex, and is covered in detail in Landfill Gas and Leachate Control Applied to Arable After-use (MAFF November 1998 PR4869).

**b. appropriate access arrangements for monitoring and maintenance of wellheads etc**

Wellheads, pipework controls and sampling points will require access for vehicles for monitoring and maintenance purposes. These access routes should be designed and laid out to minimise interruption to the after-use, and damage to the land surface. Dedicated haul routes should reduce the incidence of vehicles driving randomly over the site and should, wherever possible, satisfy the needs of agricultural access, and be routed along boundaries.