PART G

ROAD MAINTENANCE
Some material for this document has been taken from the World Road Association (PIARC) International Road Maintenance Handbook. Additional images have been provided by Intech Associates. Diagrams are by Patricia Petts. The first draft of this Manual was prepared with the assistance of Intech Associates under the direction of Ti-UP with funding of the UK Department for International Development.

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Part or all of this document may be copied, adapted or translated, provided the source is acknowledged.
This Manual has been developed by the Ethiopian Road Authority as one of a number of initiatives to help rapidly expand, develop and maintain the rural road network to provide greatly improved road access and lower the transport costs for rural communities.

The Manual specifically sets out guidance for weredas, kebeles and all local communities on how to maintain their own road access using the limited resources available to them. It also advises how it may be possible to mobilise outside resources to enhance the impact of local initiatives.

By focussing on the use and mobilisation of available local resources, such as locally occurring materials, enterprises, and local labour and skills, it is entirely possible to build and maintain durable all-weather roads suitable for all traffic from pedestrians and animal transport up to buses and trucks.

The Manual advises:

- What needs to be done to achieve all-year Basic Road Access;
- How to identify the main problems/defects on roads and how to solve them;
- How to make the most of local materials and skills;
- How to maintain the road access at low cost;
- How to maintain drainage and other structures
- How to set priorities
- How to organise and plan the work
- Where to obtain further advice and outside assistance.

The maintenance activities and codes are based on the ERA Maintenance Technical Specifications with refinement for application to LVRs.
Figure 2.1 shows the typical Road Cross Section (imagine a vertical slice through the road).

![Figure G.2.1: Typical Road Cross Section](image)

The camber is required to shed rainwater to each side of the road. Side drains (ditches), mitre drains (turnout drains), drifts and culverts are required to manage the water collected from the road surface and to discharge it safely away from the road, avoiding erosion or other problems. The road surface normally needs to be slightly higher than the surrounding ground in order for the drainage system to function effectively.

![Figure G.2.2: Importance of Road Camber](image)

For roads on free draining, unbound sand in dry flat areas, it is desirable to keep the road surface level with no physical drainage provision. If water is allowed to flow across slopes and in drains on sandy soils, it will cause erosion.

Figure 2.3 shows the typical drainage features on a rural road.
Figure G.2.3: Typical Drainage Features

The Terminology Section (Chapter 11) provides the explanation for each road term or feature.
3.

ROAD SURFACE TYPES

Low Volume Roads serving weredas, kebeles and other communities are normally constructed to gravel, stone aggregate or earth standard. As resources become available, other surface types may be introduced on a spot improvement or whole link basis.

All road surface types require maintenance.

This manual focuses on the maintenance of the commonly used ‘unpaved’ surface types, however reference is made to the other types of surfacing that may become more commonly used.

Many natural soils can be built into an Earth Road, which is also known as an “Engineered Natural Surface” (ENS). However, for road sections on weak soils, or if traffic increases to more than about 50 motor vehicles per day, or on steep hills, or through settlements, it may be necessary to improve the road surface with gravel or various types of paving.

The surface types that may be encountered on Low Volume Roads and requiring maintenance include:

- Engineered Natural Surface (ENS)
- Natural gravel (including crushed and screened material)
- Waterbound / Drybound Macadam
- Hand Packed Stone
- Stone Setts or Pavé
- Mortared Stone
- Dressed stone / Cobble stone
- Fired Clay Brick, Unmortared / Mortared joints
- Bituminous Sand Seal
- Bituminous Slurry Seal
- Bituminous Chip Seal
- Bituminous Cape Seal
- Bituminous Otta Seal or Gravel Seal
- Bituminous Cold Mix Asphalt
- Non-reinforced concrete
- Reinforced concrete.

Examples of improved surfaces are shown in Figure 3-1.

Figure G.3.1: Examples of Alternative Surfacings for Low Volume Roads

PART G: ROAD MAINTENANCE
Gravel is the most common form of improved surfacing for rural roads. However, care should be taken in using gravel as a road surface. For example, research has shown that it is unlikely that gravel will be suitable as a surfacing option under the conditions listed below. This is due to the high cost of replacement of gravel lost as a result of erosion or traffic. It may also be due to dust nuisance:

- Traffic is more than 200 motor vehicles per day
- Annual rainfall is greater than 2,000 mm
- The slope of road surface is more than 6%
- The road passes through a community settlement
- The haul distance from the gravel quarry/pit to the road site is more than 10km
- The road section experiences frequent flooding
- The gravel is of poor quality.

**Figure G.3.2: Erosion of Gravel on a Hill Section and Dusty Conditions**

Despite initial low construction costs, it is important to appreciate it is essential to arrange the necessary Regular Maintenance of the ENS and any gravel surface, the drainage system, and Occasional Maintenance of the improved surface sections.

Maintenance is vital to preserve the considerable investment in road construction and to provide the continued level of access and service to the community.
From the moment that a road is constructed or upgraded, it will deteriorate due to the effects of weather and traffic. Maintenance is required to be carried out from time to time to restore the condition of the road to be close as possible to its as-constructed state. If maintenance is not carried out the road will continue to deteriorate making passage increasingly difficult, uncomfortable and expensive to road users. The road may even become impassable for part or all of the year.

It is convenient to view Maintenance as correcting Defects.

In practical terms it is useful to identify and quantify the Defects, and then arrange the necessary Maintenance to be carried out. In this Manual Defects and Maintenance Activities are grouped as follows:

**Regular Maintenance**
- Roadside activities
- Drainage
- Road surface
  - Earth Road
  - Gravel Road

**Occasional (Periodic) Maintenance**
- Road surface
  - Gravel Road
  - Paved Road and Alternative Surfacings

**Bridges and Structures.**

From time to time, other activities not covered in detail by this Manual may be required. Advice should be obtained from the Regional Road Authorities for any problem or road aspect not covered in this Manual.

Fully funded maintenance of rural roads will require approximately 3% to 5% of the initial investment construction cost of the road each year. Failure to resource and carry out proper maintenance can result in deterioration and loss of the road asset value of more than 15% each year.
Road Maintenance activities require a range of simple and inexpensive tools and control aids. However, construction quality tools are preferable to agricultural quality tools, as they are more durable. References No. 4 and No. 5 in Chapter 10 provide specification guidance on the design and specification for road works hand tools.

Figure G.5.1: Road Maintenance Hand Tools
6.1 Regular (Routine) Maintenance

Regular maintenance activities are likely to be required somewhere on a road link every year. Most of the tasks may be carried out manually. Mechanised alternatives are available for some tasks as indicated. Regular Maintenance is divided into three main groups of activities that are often carried out on a seasonal basis:

- Roadside activities
- Drainage
- Road surface
  - Earth Road
  - Gravel Road

6.1.1 Roadside Activities

The typical roadside maintenance activities are summarised in Table G.6.1.

<table>
<thead>
<tr>
<th>Defect Description</th>
<th>Maintenance Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-01 Grass on shoulder or in drain requires cutting</td>
<td>1-01 Cut grass (manual or mechanised)</td>
</tr>
<tr>
<td>1-02 Trees and bushes growing on roadside</td>
<td>1-02 Bush clearing</td>
</tr>
<tr>
<td>2-01 Shoulder uneven or eroded, or does not drain properly</td>
<td>2-01 Shoulder rehabilitation (manual)</td>
</tr>
<tr>
<td>2-02 Shoulder uneven or eroded, or does not drain properly</td>
<td>2-02 Shoulder rehabilitation (mechanised)</td>
</tr>
<tr>
<td>2-03 Shoulder uneven or eroded, or does not drain properly (minor)</td>
<td>2-03 Shoulder Blading (mechanised)</td>
</tr>
<tr>
<td>3-01 Shoulder erosion</td>
<td>3-01 Plant grass and water it</td>
</tr>
</tbody>
</table>

6.1.2 Drainage Activities

The typical maintenance activities for the road drainage system are summarised in Table G.6.2.

<table>
<thead>
<tr>
<th>Defect Description</th>
<th>Maintenance Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-01 Culvert/Drift silted/obstructed</td>
<td>4-01 Culvert/Drift Cleaning</td>
</tr>
<tr>
<td>4-02a Drain silted</td>
<td>4-02a Drain Cleaning (manual)</td>
</tr>
<tr>
<td>4-02b Drain silted</td>
<td>4-02b Drain Cleaning (mechanised)</td>
</tr>
<tr>
<td>5-01 Drain or slope eroded (minor)</td>
<td>5-01 Repair Erosion Damage (selected fill)</td>
</tr>
<tr>
<td>5-02a Drain or slope eroded (major)</td>
<td>5-02a Repair Erosion Damage (rock fill)</td>
</tr>
<tr>
<td>5-02b Slope eroded (major)</td>
<td>5-02b Terracing or Wattling</td>
</tr>
<tr>
<td>6-01 Mortared Masonry damaged</td>
<td>6-01 Mortared Masonry Repair</td>
</tr>
<tr>
<td>6-02 Dry Masonry damaged</td>
<td>6-02 Dry Masonry Repair</td>
</tr>
<tr>
<td>7-01 Gabion structure damaged</td>
<td>7-01 Gabion Structure Repair</td>
</tr>
<tr>
<td>8-01 Erosion in drain</td>
<td>8-01 Build stone/wooden scour check</td>
</tr>
</tbody>
</table>
6.1.3 Road Surface

Defects and maintenance requirements for the road surface depend on the road surface type. The requirements for earth roads are different from the requirements for gravel roads.

**Earth Roads**

The typical activities for the maintenance of the carriageway on earth roads are summarised in Table G.6.3.

**Table G.6.3: Earth Roads Carriageway Maintenance Activities**

<table>
<thead>
<tr>
<th>Defect</th>
<th>Maintenance Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-01 Road surface potholed, rutted or uneven, and does not drain to shoulder</td>
<td>9-01 Reshape &amp; Compact Earth Road Camber</td>
</tr>
</tbody>
</table>

6.1.4 Gravel Roads

The typical activities for the maintenance of the carriageway on earth roads are summarised in Table 6-4.

**Table G.6.4: Gravel Roads Carriageway Maintenance Activities**

<table>
<thead>
<tr>
<th>Defect</th>
<th>Maintenance Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-01 Road Surface potholed</td>
<td>10-01 Spot Repair Selected Material</td>
</tr>
<tr>
<td>10-02 Road Surface potholed</td>
<td>10-02 Spot Repair Crushed Aggregate</td>
</tr>
<tr>
<td>11-01 Road Surface rutted or uneven, and does not drain to shoulder (Minor: &lt;3cm)</td>
<td>11-01 Blade Gravel Road (light)</td>
</tr>
<tr>
<td>12-01 Road Surface rutted or uneven, and does not drain to shoulder (Major: &gt;3cm)</td>
<td>12-01 Blade Gravel Road (heavy)</td>
</tr>
</tbody>
</table>

6.2 Occasional (Periodic) Maintenance

Occasional maintenance activities are required on a gravel or paved road after a period of a number of years. The category of repair depends on the type of road surface constructed. All of the Occasional Maintenance tasks may be carried out manually with the aid of simple tools or equipment, and material haulage transport.

If crushed aggregate is used for regravelling works it may lack plastic fines and therefore be prone to ravelling. It is preferable to use high quality natural gravel (where available) rather than crushed aggregate.
### Table G.6.5: Gravel or Paved Road

<table>
<thead>
<tr>
<th>Defect</th>
<th>Maintenance Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-01 Gravel layer too thin</td>
<td>13-01 Gravel Resurfacing (Selected Material)</td>
</tr>
<tr>
<td>14-01 Paved road pothole or surface defect</td>
<td>14-01a Spot/Pothole Repair (Macadam)</td>
</tr>
<tr>
<td></td>
<td>14-01b Spot/Pothole Repair (Stone setts)</td>
</tr>
<tr>
<td></td>
<td>14-01c Spot/Pothole Repair (Mortared stone)</td>
</tr>
<tr>
<td></td>
<td>14-01d Spot/Pothole Repair (Dressed stone)</td>
</tr>
<tr>
<td></td>
<td>14-01e Spot/Pothole Repair (Emulsion chip seal)</td>
</tr>
<tr>
<td></td>
<td>14-01f Spot/Pothole Repair (Emulsion sand seal)</td>
</tr>
<tr>
<td></td>
<td>14-01g Spot/Pothole Repair (Emulsion gravel/ slurry seal)</td>
</tr>
<tr>
<td></td>
<td>14-01h Spot/Pothole Repair (Un-mortared brick)</td>
</tr>
<tr>
<td></td>
<td>14-01i Spot/Pothole Repair (Mortar jointed brick)</td>
</tr>
<tr>
<td></td>
<td>14-01j Spot/Pothole Repair (Non-reinforced concrete)</td>
</tr>
<tr>
<td></td>
<td>14-01k Spot/Pothole Repair (Reinforced concrete)</td>
</tr>
<tr>
<td></td>
<td>14-01l Pothole Reinstatement (cold mix)</td>
</tr>
<tr>
<td></td>
<td>14-01m Pothole (Base Failure Repair)</td>
</tr>
</tbody>
</table>

### Table G.6.6: Road Signs

<table>
<thead>
<tr>
<th>Defect</th>
<th>Maintenance Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-01 Road Sign dirty</td>
<td>15-01 Cleaning Road Sign</td>
</tr>
<tr>
<td>16-01 Road Sign paint defective</td>
<td>16-01 Repainting Road Sign</td>
</tr>
<tr>
<td>16-02 Road Sign damaged/missing</td>
<td>16-02 Replace Road Sign</td>
</tr>
</tbody>
</table>

Maintenance of bridges and large drainage structures is a topic requiring specialist skills & knowledge and is covered in outline in Appendix G1.

### 6.3 Maintenance Activities

Each of the typical road defects is described in the following schedules along with a description of the maintenance activity required to remedy the defect.

Whenever works are carried out on the road surface warning signs should be placed before each end of the work site.
## Defects

### 1-01 Grass, weeds, bushes or trees overgrown on the roadside

<table>
<thead>
<tr>
<th>Development, if neglected</th>
<th>Maintenance Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Drainage ditches cannot be cleaned;</td>
<td>1-01 Grass Cutting (Manual or Mechanised)</td>
</tr>
<tr>
<td>- Surface water can pond at the edge of the road and weaken the road surface;</td>
<td></td>
</tr>
<tr>
<td>- Silt can accumulate at the edge of the road;</td>
<td>1-02 Bush Clearing</td>
</tr>
<tr>
<td>- The visibility for road users is reduced, with increased risk of accidents with persons</td>
<td></td>
</tr>
<tr>
<td>or animals;</td>
<td></td>
</tr>
<tr>
<td>- Increased fire hazard in the dry season.</td>
<td></td>
</tr>
</tbody>
</table>

These activities may be required individually or together. With the exception of arid areas, these are Regular Maintenance activities, involving control of grass, weeds, bush and trees where these are not controlled by animal grazing. They may be required to be carried out at least once a year after the rainy season, or more often where the climate causes vegetation to grow rapidly.

### Grass Cutting

- Required in the moister, humid regions. Grass and weeds should be cut at least once a year after vegetation reaches full growth or according to local experience. The vegetation should be trimmed by hand. Sickles, scythes, slashers, bush knives, or similar hand tools will be required.
- Alternatively, the grass may be cut by mechanised methods; such as by tractor powered mower.

### Bush control & Trees

- Any bushes on the road shoulders or drains should be cut down. Dead or leaning trees within the right-of-way which may fall on the roadway or block the drainage system, or block sight lines should be removed. The felling of trees, or the removal of large branches at heights of more than 2 metres above ground level can be hazardous. This work should only be carried out under expert supervision or by experienced workers. Trees should be felled using one- or two-man saws or axes. Ladders should be used for climbing trees, and ropes should be used to restrain trees and control felling. Traffic should be halted when the tree is finally toppled. All debris should be removed and disposed of safely.

### Disposal of debris

- All cuttings and debris should be disposed of safely so that there is no risk of drains being blocked or fire hazard.
**Herbicides**

Herbicides (weed-killers) are chemical agents intended to destroy or reduce vegetation growth. It is not recommended that herbicides or any chemical methods be used to control roadside vegetation. Herbicides can cause pollution of crops, rivers and streams and drinking water supplies. They are often dangerous to health and require training in their safe use. They are expensive, and must often be imported, and may not always produce satisfactory results.

**Burning**

Do not burn roadside vegetation to control its growth or the debris from bush clearing activities. The results may be more harmful than desired:

- The fire could spread and destroy valuable vegetation (trees, grass or crops), and traffic signs;
- Vegetation may grow faster after burning;
- Smoke and flames blowing across the road are dangerous for traffic.
| Defect  
| 2-01  
| 2-02  
<table>
<thead>
<tr>
<th>2-03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder eroded, mis-shaped or does not drain away from roadway</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Development, if neglected</th>
</tr>
</thead>
</table>
| • Hazard to road users, increased risk of accidents;  
| • Obstruction of water flow off the roadway;  
| • Inadequate support for the road surface;  
| • Water collects and softens/weakens the shoulder and pavement;  
| • The edge of the pavement will break when vehicle wheels run over it;  
| • The roadside drain may become blocked by the excess material. |

### Maintenance Activities

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
</table>
| 2-01 Shoulder Rehabilitation (manual);  
| 2-02 Shoulder Rehabilitation (mechanised);  
| 2-03 Shoulder Blading (mechanised). |

#### a) Shoulder Rehabilitation Manual Method (2-01)

The low surfaces and all high material should be loosened with a pick axe or mattock. The shoulder should be reshaped to slightly above the final level and the correct crossfall using a shovel and rake. Any low spots should be topped up with fresh material of the same type and quality as the existing shoulder. The crossfall of the uncompacted material should be checked with a camber board. Excess material should be spread over the embankment slope or transported by wheelbarrow to a convenient and safe dumping site. Material should not be deposited on the roadway or in the drainage ditch. If the material is dry it should be sprinkled with water. The shoulder is then compacted with hand rammers or a hand roller. The compacted surface should butt smoothly onto the roadway. Check the finished crossfall with the camber board and repeat the reshaping if necessary. Brush all loose material and debris from the roadway.
b) Shoulder Rehabilitation Mechanised Method (2-02)

The existing surface of the shoulder should be scarified with the tines of a motor or towed grader. This will loosen the raised areas and allow the loosened material to key into any existing low areas. The shoulders should be reshaped to slightly above the final level and the correct crossfall using a number of passes of the motor or towed grader blade. Care must be taken not to damage the edge of the roadway with the blade. Any low spots should be topped up with fresh material of the same type as the existing shoulder. The cross fall of the uncompacted material should be checked with a camber board. Excess material and vegetation should be graded to the embankment side slope. In cuttings, excess material and vegetation should be graded into a windrow for removal by wheelbarrow, tractor and trailer or truck. Material should not be deposited on the roadway or into the drainage ditch. If the material is dry it should be sprinkled with water. The shoulder is then compacted using a self-propelled, towed or pedestrian roller. The compacted surface should butt smoothly onto the roadway. Check the finished crossfall with the camber board and repeat the reshaping if necessary. Brush all loose material and debris from the roadway.

c) Shoulder Blading (mechanized) (2-03)

This regular maintenance activity may be carried out if no additional material is required to be added to the shoulder. The shoulder material should contain sufficient moisture to enable the reshaped material to be compacted by the grading equipment or a roller. It is therefore ideally carried out in the rain season. Otherwise, water should be added to ensure a more durable surface finish.
## Defect 3-01

### Shoulder or slope erosion protection

**Development, if neglected**
On some steep slopes or erodible soils, surface scour may occur if vegetation cover is not established. This could cause damage to the roadway, shoulders, drainage system or earthworks.

### Maintenance Activities

**3-01**
Plant grass and water it.
May be required as follow up to Activity 5-01

**a) Seeding**

Grass seeding will only be successful if climate and soil conditions are favourable. The best advice can be provided by the local department of agriculture on:

- Topsoil required;
- Seed type, rate of spread;
- Fertilizer types, rate of spread;
- Most favourable season and weather for seeding;
- Other preparatory treatment of the soil (for example mixing-in ground limestone).

**Typical procedure:**

- Loosen the soil to a depth of 10 cm in the area to be seeded using rakes or similar tools;
- Spread the topsoil to a depth of at least 5 cm;
- Water the area to be seeded;
- Apply fertiliser at the specified rate;
- Apply ground limestone at the specified rate and mix in; apply seeds by hand at the specified rate;
- Lightly roll the seeded area within 24 hours using hand roller, only if the soil does not adhere to the roller;
- The seeded area should be watered as required until the grass has taken hold.
b) Turfing (grass sodding)

This method is suitable when climate and soil conditions are favourable and when fresh grass sods (soil clumps containing grass and its roots) are available.

The general procedure is:
- Prepare the area to be turfed to required levels and slopes;
- Where no topsoil is present, haul suitable topsoil to site and spread evenly to a depth of not less than 5cm;
- Water as required;
- Cover the area with freshly cut sods without weeds. Sods are to have thickly matted roots which should not have dried out. Tamp sods with tamper or use hand roller. On slope use stakes to hold sods in position;
- Water the turves at intervals until the grass takes hold.

Other patterns of sodding are:
- Spot sodding (sods spaced about 50cm in holes deep enough to take sod and about 5cm topsoil);
- Trench sodding. Lay sods on 5cm topsoil bed in parallel trenches;
- Trench spacing about 50cm along contour or x-shaped pattern.
### Defect 4-01

**Culvert or Drift silted or obstructed with debris**

### Development, if neglected

The intended waterway opening will be so reduced that flood water cannot flow as intended. Flood water will back-up or pond on the upstream side of the culvert/drift and may eventually over-flow the road embankment. The road is then in danger of being washed away.

### Maintenance Activities

| 4-01  | Culvert or Drift Cleaning |

In order to function properly, a culvert must retain the full opening over its complete length. In addition, the upstream approaches and the downstream area must be free of obstructions. Floating debris (tree branches, bushes, etc.) carried by water is a great danger to culverts. The debris may completely block the culvert inlet. The following Regular Maintenance activities may be required:

- Clear any sand, silt or debris from inside the culvert. Sanding or silting of culverts, especially those with openings smaller than 1 metre, can be a particular problem. These culverts can be cleaned by pulling a cable or rope through, to which is attached any suitable object (e.g. a bucket). Alternatively, a long handled trowel and spike can be used.
- If the silting problem continues despite regular clearing, it may be necessary to reconstruct the culvert at a higher level or enlarge it.
- Material and debris from the culvert must be spread or dumped where they cannot cause an obstruction to water flow, preferably on the downstream side of the culvert, well away from the watercourse.
- Drifts should be cleared of debris and also upstream and downstream areas.
- This Maintenance task is best carried out before the rains and after any heavy rainstorm.
Defect 4-02

Drain silted
Drain partially or fully blocked by vegetation growth, bushes, fallen trees, debris, loose silt, loose rocks.

Development, if neglected
Concentration of flood flow causing erosion and possible overtopping and damage to roadway, paving or shoulders.

Maintenance Activities
4-02a Drain Clearing (Manual);
4-02b Drain clearing (Mechanised).

a) Manual Method (122)
This is a Regular Maintenance activity. The object is to remove all soil, high vegetation, materials and objects from the drain which could possibly interfere with water flow or cause an eventual blockage of the drain. This can include for example, rocks, loose silt and sand, weeds, trees, bushes, including their roots, etc. Dispose of these materials well away from the roadside so that water flow will not be impeded and they will not fall or wash back into the drain. Normally NO soil material or debris should be placed on the roadway, unless it is of good quality. On unlined drains a short grass cover can help to stabilise the bottom and sides of the drain. Therefore, where a side drain is established to the correct depth and profile with grass cover and no erosion, it is advisable to merely cut the grass short. This will leave the roots in place to bind the drain surface together.

At some locations it may be necessary to RESHAPE/REGRADE/DEEPEN the drain. It is advisable to adopt a trapezoidal drain shape when using labour methods. The excavation using a hoe/mattock and shovel is easier than for a V-shaped drain. An added advantage is that the flat invert causes less concentration of water than a V-drain.
A ditch and slope template should be used to obtain the correct drain shape.

Using the template a 50 cm wide slot should be excavated to the correct drain shape every 10 metres along the drain. The slots act as a guide for excavating the drain to the correct shape;

In flat areas, the gradient of the drain should be checked using ranging rods and profiles or similar methods, to ensure that water will not pond. The levels at adjacent slots should be checked using a line and level or Abney Level, and the level of the slot adjusted if necessary.

Excavate all surplus material between the slots and to the correct shape with the aid of stringlines stretched between the slots. If necessary, the intermediate invert levels can be checked using a traveller sighted between the ranging rod profiles.

Material excavated from the drain must be removed and spread well clear of the drain so that it cannot later fall or wash back into the drain.

The shape can be checked during the excavation activity using the drain template.

When excavating a completely new drain it is preferable to split the task into two operations:

i. Cut the central rectangular shape and check with a template (INVERT);

ii. Cut the slopes and check with the full drain & slope template (SLOPES).

The alignment or route of the drain should be set out using string-lines and pegs. The ranging rods and profiles should be set up at the start and outfall of the drain. Intermediate profiles may be required on long drains. The levels of intermediate slots can be determined using the traveller.

This maintenance task is best carried out before the rains and after any heavy rainstorm.
### b) Mechanised Method (4-02b)

This activity is suggested where long sections of V-shaped drains are to be maintained and cleaned and where high daily outputs are possible. The activity may be carried out by a motor or towed grader. The grader should always work by cutting in the direction of water flow in the drain.

#### Case 1

When the grader can operate only on the shoulder and in the drain, but not beyond the drain:
- Start by grading the outside slope of the drain, using the blade to windrow the soil to the bottom of the drain between the rear wheels. (This can be repeated to obtain the desired depth of drain. This part of the task can also be done manually);
- The next blade pass(es) are to clean the invert of the drain by removing the windrow to the top of the drain at road shoulder;
- The final pass is required to move the windrow material away from the shoulder drain edge. If the recovered material quality is inferior to that of the road surface, THE MATERIAL MUST BE REMOVED FROM THE SITE.
- On completion, the drain should generally have a depth of 50 cm (minimum), which can be checked with a ranging rod and tape/rule;
- If necessary the grade of the drain invert can be checked using the methods described in a) Manual Method (4-02a).

#### Case 2

When the grader can operate beyond the drain. Reverse the operations shown previously:
- Grade the inside slope, windrowing material to the bottom of the drain. Repeat as necessary to achieve the desired depth of drain;
- Remove the windrow material to the top of the outside slope;
- Move windrow away from drain edge and spread the material so that it will not wash back into the drain;
- On completion, the drain should have a depth of 50 cm (minimum), which can be checked with a ranging rod and tape/rule;
- If necessary the grade of the drain invert can be checked using the methods as described in a) Manual Method (4-02a).

In some situations the grader can be used to clean turn out drains.
### Defect 5-01

**Drain or slope eroded (minor)**

<table>
<thead>
<tr>
<th>Development, if neglected</th>
<th>Damage to drainage system, roadway, structures, paving or shoulders.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maintenance Activities</strong></td>
<td><strong>5-01 Repair Erosion Damage (Selected Fill).</strong></td>
</tr>
</tbody>
</table>

This activity may be sufficient for minor erosion damage to a drain. However, reconstructing the drain profile with selected fill material alone may not be sufficient to prevent the defect recurring within a short time. Loose stones or boulders should be removed. The defective section of drain should be cut back to firm material and fresh material placed in layers not exceeding 15cm thickness and compacted with a hand rammer. If the material is dry it should be sprinkled with water before compaction. The added material should be trimmed back to the correct drain profile and checked with the drain template. Dispose of the excess materials well away from the roadside so that water flow will not be impeded and they will not fall or wash back into the drain.

Check Dams (scour checks) may need to be installed to prevent recurrence. Similar minor repairs may be carried out to eroded slopes (illustrated).

It is likely that additional measures will be required such as:
- **3-01** Plant grass and water;
- **5-02a** Repair Erosion Damage (rockfill);
- **8-01** Build stone/wooden Check Dam;
- **5-02b** Wattling or Terracing
## Defect 5-02

### Drain or slope eroded (major)

### Development, if neglected

Damage to drainage system, roadway, structures, earthworks paving or shoulders.

### Maintenance Activities

5-02a
Repair Erosion Damage (rockfill);
5-02b
Terracing or Wattling;
5-02c
Stone pitching.

A number of activities are possible to repair erosion damage to drains and slopes. However, it is important to try to determine the cause of the erosion so that the repair will minimize the risk of it recurring. It is advisable to obtain Engineer’s advice where erosion is extensive.

### Drains (Open Ditches)

Drain sections are often laid at a steep gradient or on sharp bends without erosion protection along or at the outfall of the drain. The following options should be considered:

- Repair the drain with rockfill lining
- Repair the drain with timber lining;
- Provide masonry lining;
- Regrade/Realign drain;
- Provide relief drain or culvert.
## Slopes

Slips or slope erosion/instability are usually caused by adverse ground conditions or ground/surface water or both. The remedial works should be specified by an Engineer after an inspection of the site and the necessary investigations. Works are likely to be expensive and it is important to ensure an appropriate solution is adopted. Dealing with slips and unstable slopes is hazardous and particular care should be taken to safeguard manpower, equipment and the road users. The cheapest solution (if appropriate) is expected to be Watling. Other, but more expensive, remedial options are:

- Counterfort drains;
- Stone pitching the slope;
- Reducing slope angle;
- Clearing slip material;
- Surcharging the slope with rocks;
- Gabions;
- Cribwork;
- Terracing
- Masonry retaining wall;
- Concrete retaining wall.

## Wattling (5-02b)

This activity may be suitable after repairing an eroded slope with Maintenance Activity: 5-01 Repair Erosion Damage (Selected Fill)

Watling will help to resist surface water erosion of a slope. Wattles are bundles of plant stems up to 3 metres long, tied together and laid in shallow trenches, staked into position on contour lines (lines of the same height), or x-form lines. As with turfing and seeding, a favourable climate and soil conditions are essential for the successful use of watling. Watling helps to stabilize slopes, reduce surface erosion and provides a bench on which grass can become established. Plant stems which root easily are preferred. Advice on suitable plants and planting time should be obtained from the local department of agriculture.

**Typical procedure:**

- Cut watling stems at suitable source and transport them to site immediately. Stems should not be allowed to dry out;
- Tie bundles of stems 15 - 20 cm diameter, alternating the ends;
- Excavate a trench in the slope along the desired line. The trench should be deep enough to accommodate tied watling stems (this work can be completed beforehand);
- Place watling stems in trench and use stakes to fix them in position. Overlap bundles and stake through the overlaps;
- Cover the watling with topsoil and tamp them firmly in place;
- Watering may be necessary until the roots take hold.
<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terracing (5-02b)</td>
<td>This technique is used extensively and utilises the in-situ stones to stabilise slopes and encourage vegetation growth.</td>
</tr>
<tr>
<td>Stone Pitching (5-02c)</td>
<td>This technique can be used where there is a ready supply of quality stone.</td>
</tr>
</tbody>
</table>
### Mortared Masonry Damaged

<table>
<thead>
<tr>
<th>Defect</th>
<th>Mortared masonry damaged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development, if neglected</td>
<td>Further damage to structure or roadway, slope or structural failure.</td>
</tr>
<tr>
<td>Maintenance Activities</td>
<td>6-01 Mortared Masonry Repair</td>
</tr>
</tbody>
</table>

This activity should only be carried out on masonry structures in reasonably good condition. It is recommended that the structure be completely rebuild if it is in danger of collapse.

- Clean and rake out defective joints of weak mortar, soil and vegetation using compressed air or a water spray, hammer and chisel;
- At locations where the joint has to be completely renewed, the stone or brick should be eased out of place temporarily until a new mortar bed is placed;
- Replace missing stones with sound pieces;
- Use templates and stringlines if necessary to ensure the correct shape and incline of the face of the mortared masonry work;
- Dampen the joint surfaces where fresh mortar has to be applied;
- Mix a mortar of cement and sand as required or specified (normally 1 cement: 4 sand) and add only enough water to permit mortar to be well mixed and applied;
- Apply fresh mortar to joint, filling all space available, compacting with a suitable wooden rammer. Do not use mortar which has fallen on the ground;
- Smooth joints with a suitable tool (a piece of rubber or plastic water hose, or bent reinforcing steel);
- The final mortar surface should be inset slightly from the stone/brick surface to achieve a tidy finish;
- In dry or windy weather conditions, mortar can dry out too quickly. Prevent this by sprinkling water on joints after the mortar has set and until mortar has completely hardened. Alternatively cover the work area with wet jute sacks or similar;
- Clean visible stone or brick surfaces which have been stained by mortar or cement-water in the process of the work so that the finished work will present a neat appearance;
- Remove surplus materials and leave the site in a clean and tidy condition.
### Defect 6-02

**Dry masonry damaged**

<table>
<thead>
<tr>
<th>Development, if neglected</th>
<th>Further damage to structure or roadway, slope or structural failure.</th>
</tr>
</thead>
</table>
| **Maintenance Activities** | **6-02**  
**Dry Masonry Repair**  
Try to use the established local dry stone construction techniques and skills. |

This activity should only be carried out on dry masonry structures in reasonably good condition. It is recommended that the structure shall be reconstructed if it has settled or is in danger of collapse.

- Carefully take down the defective areas of dry stone masonry, stacking the stone for re-use;
- Clean and rake out defective joints of soil and vegetation using hammer and chisel, and brush;
- Re-build the dry stone work using the salvaged stones and carefully selecting each stone to ensure good bonding horizontally and through the width of the stonework. Use smaller stones to wedge the larger ones where necessary;
- Add new stones if necessary;
- Use templates and stringlines if necessary to ensure the correct shape and incline of the face of the dry masonry work;
- Pack the spaces between stones with soil or gravel;
- Weak areas or cappings may need to be strengthened with mortar jointing;
- Remove surplus materials and leave the site in a clean and tidy condition.
Gabion Structure Repair

Gabions are usually made of zinc coated steel baskets, although they may also be made from welded mesh sheets, galvanised chainlink fencing and woven wire depending on the circumstances and locally available materials. The baskets are hand-filled with rock and stones between 12 and 30 cm size. In this way they attain great stability, but will allow minor settlement. Repairs may be required due to bulging or breaking of the basket due to excessive foundation or backing movement, or settlement of the stones within the basket. Gabions are designed to allow some settlement. Repairs should aim to ensure that the stone continues to be contained. Repairs will normally consist of opening the baskets, re-packing the stone inside, topping up stone if necessary and re-securing the lid of the gabion. It may be necessary to weave new cage material over broken or deformed areas, and any suitable steel mesh or woven sheets can be used for this.

Where a gabion box is required to be replaced or added, the procedure for building a new gabion box should be used as follows.

1. Assemble cage
2. Weave boxes securely together
3. Stone and stretch cages to required shape
4. Intermediate bracing
5. Winkel bracing
6. Close and secure lid

The gabion baskets are normally supplied folded flat complete with tying wire so that the transport volume is minimised. Foundations should be excavated level and cleaned as for a conventional structure, with any unsuitable material removed and replaced with good soil, stone or gravel, and compacted. The baskets should be erected in their final position.
Cages should be woven together using 3 mm binding wire securing all edges every 15 cm with a double loop. The binding wire should be drawn tight with a pair of heavy duty pliers and secured with multiple twists (1 and 2). The centre gabion only should be filled initially to act as an anchorage. The connected baskets should be stretched and staked with wires and pegs to achieve the required shape (3). Filling should be carried out by hand using hard durable stones not larger than 250 mm and not smaller than the size of the mesh. The best size range is 125 to 200 mm. The stones should be tightly packed by hand (NOT dumped in the baskets by machine) with a minimum of voids. Boxes of 1 metre height should be filled to 1/3 height. Horizontal bracing wires should then be fitted and tensioned with a windlass to keep the vertical faces even and free of bulges (4 and 5). Further bracing should be fixed after filling to 2/3 height. 500 mm height boxes should be braced at mid height only. 250/330 mm deep gabions do not require internal bracing. The stones should be carefully packed to about 3 to 5 cm above the top of the box walls to allow for settlement. Smaller material can be used to fill the voids on the top face, but excessive use of small stones should be avoided. The lids are then closed and stretched tightly over the stones, (carefully) using crowbars if necessary (6). The corners should be temporarily secured to ensure that the mesh covers the whole area of the box. The lid should then be securely woven to the tops of the walls removing stones if necessary to prevent the lid from being overstretched.

Stones must be larger than mesh size

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✅
<table>
<thead>
<tr>
<th>Defect</th>
<th>Erosion in drain</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Development, if neglected</strong></td>
<td>Damage to drainage system, roadway, structures, paving or shoulders, and possibly adjoining land/property.</td>
</tr>
<tr>
<td><strong>Maintenance Activities</strong></td>
<td><strong>8-01</strong> Build stone/wooden scour checks (Check Dams).</td>
</tr>
</tbody>
</table>

Unlined drains may suffer from scour of the invert and sides. Simple repairs may be achieved by filling the affected areas with soil and trimming to the correct profile, and turfing where climatic conditions are favourable. The turves will probably need to be pegged in place to retain them, and watered until established. Simple Check Dams (scour checks) may be constructed of stones or wood. Larger ones may be constructed of stone masonry, brick, gabions or concrete. They reduce the speed and erosion force of the water. They also hold back the silt carried by the water flow to provide a series of gently sloping sections of drain separated by steps.

The Check Dams must not be too high otherwise water will be forced onto the surrounding ground, the shoulder or the roadway. The Check Dam construction should therefore be controlled with the aid of a template. Check Dams should not normally be constructed on drains with gradients of less than 4%. This will encourage too much sifting of the drain and could lead to road damage. However, in the case of badly and deeply eroded drains (as shown above), check dams can be constructed at any gradient to help silt up the eroded sections. The gradient of the side drain should be checked with an Abney Level or line and level to determine the requirements for scour checks (spacing guidance in the ERA LVR Design Manual).
After the basic Check Dam has been constructed, an apron should be built immediately downstream either using stones or grass turves pinned to the drain invert with wooden pegs. The apron will help resist the forces of the water flowing over the Check Dam. Grass sods should be placed against the upstream face of the Check Dam, to prevent water seeping through the Check Dam and to encourage the silting behind the Check Dam. The long term objective is to establish complete grass cover over the silted Check Dams to stabilise them. Well-constructed Check Dams will allow the water to gently cascade over (and not through) the checks, removing energy from the water and reducing erosion power.

Gabion Check dam in eroded watercourse
Defect 9-01
Road surface potholed, rutted or uneven, and does not drain to shoulder

Development, if neglected
Road becomes waterlogged or impassable.

Maintenance Activities
9-01 Reshape & Compact Earth Road Camber.
This activity is carried out using labour, basic hand tools and control aids. The Method comprises the following steps:
- Setting out;
- Excavation of drain and slope;
- Excavation of backslope;
- Camber formation and final compaction.
Equipment methods can also be used (Activity 12-01).

Setting Out the Centre Line
- The PROFILE method of setting out enables a smooth vertical alignment to be re-established on a severely deteriorated road surface;
- The alignment will consist of straight gradients and vertical curves;
- The centre line of the road is pegged every 10 metres;
- A ranging rod is fixed at each 10 metre peg;
- Each ranging rod is fitted with a profile board. The profile board can slide up and down the ranging rod and be clamped at any height.
Setting Out a Gradient

Setting out is arranged in sections of 60 to 100 metres, which approximate to either a straight gradient or vertical curve on the road line. Check that the amount of earthworks at each centre line (finished level) peg is acceptable, or repeat the procedure using different assumptions.

Setting Out a Vertical Curve

Different $\delta$ values will be required according to design speed (see LVR Manual Part B).
Setting out the Cross Section
Once the centre line level pegs are fixed, set out the pegs for the edge of the roadway and both sides of the drain using the tape measure, camber board and spirit level for the required road cross section. Pegs should be driven in to the required finished cross section level, or a fixed height above.

Excavate Drain and Slope
- Material is excavated from the drain and slope area and used to form the camber until the required shape of drain and slope is achieved;
- Check shape with the drain and slope template, and spirit level;
- If too much material is excavated, discard the surplus material well beyond the side drain;
- If the filling placed is greater than 15 cm deep, then it is preferable to spread and compact the fill material with rakes and hand rammers or a hand/animal drawn roller in 15-20 cm layers.
- If insufficient material is excavated to form the camber, dig additional material from the backslope or from beyond the side drain.

Camber formation and final compaction
- Continue adding material to the camber to achieve the required profile after compaction;
- Stringlines stretched directly and diagonally across the running surface between the setting out pegs can be used to check the camber shape;
- In dry conditions add water to moisten the material to help compaction;
- Compact the fill material to the final profile, preferably using a hand or animal drawn roller;
- If a roller is not available, use hand rammers or the tyres of any vehicle to uniformly compact the soil across the roadway width.

The shaped and compacted earth road surface is a suitable foundation on which one of the surface options can be constructed directly, with any necessary base or sub-base.
<table>
<thead>
<tr>
<th>Defect</th>
<th>Road Surface potholed</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-01</td>
<td></td>
</tr>
<tr>
<td>10-02</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Development, if neglected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel surface loss increases. Road becomes very rough, slowing and damaging traffic, and may become waterlogged or impassable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-01 Spot Repair – Selected Material;</td>
</tr>
<tr>
<td>10-02 Spot Repair – Crushed Aggregate.</td>
</tr>
</tbody>
</table>

Potholes and ruts should be repaired with materials similar to the surrounding surface. This can be either selected gravel material (10-01) or crushed stone aggregate (10-02) with sufficient fines to bind the material together. Natural gravel material is normally preferable to crushed stone.

- Loose material and standing water is brushed from the pothole or rut to be patched;
- Large or deep potholes should have their sides cut back to be vertical and to reach sound material;
- The moisture content of the material can be checked quickly by squeezing it in the hand. If the material is wet enough to stick together, it is suitable for use. If water runs out of the material, it is too wet and should not be used;
- If the material is dry, the area to be patched should be sprinkled with water and water should also be added to the patching material.
- The area is filled with gravel to a depth of about 10 centimetres;
- If the material is dry, it should be sprinkled with water to help compaction;
- The layer is then compacted using the roller or hand rammer (in this way the thickness of the patch is built up in layers);
- Finally, the patched area is filled evenly with the gravel to approximately 3 centimetres above the level of the surface and is spread and raked to the correct shape;
- 3 centimetres is approximately the thickness of a rake handle;
- The patch is then compacted using the roller or hand rammer to give a surface which is only slightly above the level of the surrounding road to allow for further traffic consolidation;
- Both large or small areas to be patched are repaired in the same way, the rammer is used for the smaller potholes. The roller if available is used for larger areas, although the hand rammers will still be required for the corners and short edges;
- Patching work started must not be left unfinished overnight. At night the site should be made safe for traffic and all signs and obstacles removed from the road.

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**PART G: ROAD MAINTENANCE**

**G - Chapter 6 - 34**

**CARRIAGEWAY MAINTENANCE – GRAVEL ROAD**
## Defect 11-01

**Road Surface rutted or uneven, and does not drain to shoulder**

*(Minor: <3cm)*

### Development, if neglected

Gravel surface loss increases. Road becomes very rough, slowing and damaging traffic.

### Maintenance Activities

**11-01 Blade Gravel Road (light)**

Light grading may be carried out with a motor grader or a tractor towed grader to correct minor defects on the gravel road surface such as corrugations, shallow ruts and flat camber. The task may also be achieved using labour with hand tools.

#### a) Light reshaping, Manual Method

- The surface material may be loosened, trimmed and reshaped with a pickaxe, hoe or mattock and rakes to form the required camber and crossfall;
- The shape is checked with the camber board and spirit level;
- If gravel stockpiles are provided, any local depressions are filled with material transported in a wheelbarrow, pannier or other carrying device;
- The loose material is compacted with the hand rammer;
- Pegs and string lines can be used to help to achieve the correct shape and camber.
b) Light reshaping, Mechanised Method

The motor grader or tractor towed grader is used to draw the surface material back to the crown of the roadway. Normally only 4 passes will be required to achieve this minor reshaping. It is best carried out during the rains when there is sufficient moisture in the material for reconsolidation under traffic, so that expensive watering and compaction operations will not be required.

Minor corrugations can be dealt with by using a low cost drag towed by a tractor or other vehicle. Drags can be made from old tyres or various arrangements of discarded steel sections.

- The tractor tows the drag at up to 5 km/hour depending on the type of drag and on the type and condition of the road surface;
- The length of pass should be as long as possible;
- The number of passes needed will depend upon the conditions and the width of the road;
- The equipment should work in the same direction as the traffic flow;
- DO NOT drive too fast or the drag will jump over the surface irregularities and raise a lot of dust, it will also cause a hazard to traffic.
### Defect 12-01

**Road Surface rutted or uneven with potholes, and does not drain to shoulder (Major: >3cm)**

<table>
<thead>
<tr>
<th>Development, if neglected</th>
<th>Road becomes very rough, slowing and damaging traffic. Water ponds on road surface. Gravel surface loss increases and danger of total gravel layer loss and road being impassable.</th>
</tr>
</thead>
</table>
| **Maintenance Activities** | **12-01 Blade Gravel Road (heavy)**  
Heavy grading may be carried out with a motor grader or a tractor towed grader. However, the task will also require towed or self-propelled watering and compaction equipment. The task may also be achieved using labour and hand tools by adapting the methods of Maintenance activity 9-01. |
<p>| <strong>Preparation</strong>           | Patching (Activity 10-01 or 10-02) of large potholes or depressions should be carried out in advance of the grading. Areas of standing water should be drained. This preparation will ease the work and make the resulting surface last longer. |
| <strong>Scarifying</strong>            | Using a motor or tractor towed grader it may be necessary to scarify the existing surface to cut to the bottom of any surface defects and loosen the material for reshaping. |
| <strong>Machine Attendants</strong>    | These help direct traffic and grader turning, and remove large stones and other unwanted material from the path of, or behind, the grader. |</p>
<table>
<thead>
<tr>
<th>Grading</th>
<th>The grader works on one side of the road at a time and works in passes about 200 metres long to convenient and safe turning points. Heavy Grading will require additional passes to achieve the required camber. Work should be completed on one side of the road at a time. An even number of passes should be used to avoid a flat finished crown. Normally initial cutting passes are required to bring material in from the edges of the road. Spreading passes redistribute the material away from the crown. The initial passes cut to the bottom of the surface irregularity and deposit a windrow just beyond the centre line.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watering</td>
<td>The towed or self-propelled water tanker sprays the windrow with water, if required. The windrow is spread back across the road depositing all the material to give the correct camber. A second application of water may be required to obtain the correct moisture content for compaction.</td>
</tr>
</tbody>
</table>
### Cambering

The aim should be to develop a proper crown on the road. The road should be cambered to fall away from the crown at a rate of about 6 to 7 cm for each metre from the centre of the road before compaction. This should achieve a crossfall of about 4 to 6 cm per metre (4 to 6%) after compaction. If there is insufficient camber, water will not drain easily from the surface of the road, potholes will form and the road will deteriorate quickly. This is particularly important on gradients, where the rain water tends to run along the road forming erosion channels. Do not make a final pass down the centre of the road with the grader blade horizontal. This flattens the centre of the road and causes water to pond leading to rapid deterioration of the surface. Do not leave a windrow on the road overnight as this is a danger to traffic.

### Compaction

When towed, self-propelled compaction plant is being used, it must follow close up behind the grader, but only on sections where grading has been completed. Usually about eight passes of a roller will be needed to achieve full compaction, working towards the centre of the road. Shoulders are treated as part of the running surface.

### Junctions and Bends

Graders and other equipment must not park up near junctions or bends where they will be a danger to traffic.

### Check the Camber

Camber should be checked with a camber board at about 100 metre intervals along the road. To use the camber board place it on its edge across the road with the shorter end pointing towards the centre line. Check the level bubble. If it is central, the camber is correct. If it is not central, the camber is either too steep or too flat and further grading and compaction are required.
Superelevation

On sharp bends on two lane width roads, the surface should be straight (at 4-6%) from shoulder to shoulder with the outer shoulder higher. This is called superelevation. This is because any crown on a sharp bend can be very dangerous to traffic. The superelevation must be retained for the complete length of the bend.

Structures

On the transition at each end of the bend into the straight sections, the superelevation should be gradually reduced until the normal cross section shape with about 1 in 25 to 1 in 17 (4-6%) crossfall is obtained again.

The shape of the road must be maintained over culverts to avoid a dangerous hump. Material should be brought in if necessary from either side of the culvert to achieve a safe vertical alignment and maintain a cover to the top of the culvert of at least 3/4 culvert diameter. Bridge decks should be kept free from gravel. Loose material should be swept away by the attendants. It is important to have smooth approaches to the bridge. They should be smoothed out using the back of the blade with the grader working in reverse, or by hand.

Blade Position

a. For most grading work, the cutting blade is set to be vertical
b. For cutting hard surfaces, the cutting blade should be set back at the top to give the most effective cutting angle. Scarifying passes should also be made before cutting.
c. For spreading, the cutting blade should be set forward at the top.
### Defect 13-01: Gravel layer too thin

**Development, if neglected:**
Road becomes very rough, slowing and damaging traffic. Water ponds on road surface. Gravel surface loss increases and danger of total gravel layer loss and road being impassable.

**Maintenance Activities:**

<table>
<thead>
<tr>
<th>Task Code</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-01</td>
<td>Gravel Resurfacing (Selected Material)</td>
</tr>
</tbody>
</table>

Gravel surfaces wear down due to the wasting effects of traffic and weather. Gravel loss rates can be up to 5cm or more of thickness each year even on a Low Traffic Volume Road. Re-gravelling will be required when (or before) the residual thickness of gravel reduces to about 5 – 8 cm, otherwise there is a danger of vehicle wheels ‘punching’ through to the weaker material below. This would result in mixing and effectively the loss of the gravel layer.

Great care should be taken in locating and selecting suitable gravel material. It should be obtained from a recognized approved source and tested to meet materials specification requirements. This can be either selected gravel material, or crushed stone aggregate with sufficient fine material to bind the material together. Natural gravel is preferable to crushed stone. Gravel should not contain any pieces larger than 3cm, as this will seriously affect performance. ‘Oversize’ pieces should be hand-picked or ‘screened’ out. Due to the high cost of re-gravelling, technical advice should be obtained on sources and material suitability. It is questionable whether re-gravelling will be cost-effective if the material has to be hauled more than 10km and other types of road surface may be more economical. Whole life cycle costing of all viable surface options should be carried out.

**Diversion?**
Wherever possible, before the re-gravelling work starts, a diversion should be opened up adjacent to the road. If traffic is diverted from the work site, it will enable the job to be carried out more efficiently and safely.
Before the regravelling work starts, gravel should be stockpiled at the quarry or borrow pit. It may also be helpful to start hauling the material to site. Plan the quarry excavations and stockpiles so that:

- The quarry can be fully exploited with economic removal of the maximum amount of gravel;
- The overburden is stockpiled so that it will not hinder future extension, and that it can be used to reinstate the quarry;
- The best material is taken, where gravel quality is variable within the quarry;
- Material is stockpiled to minimise segregation;
- Environmental damage by poor drainage and erosion is minimised both during and after exploitation of the quarry.

The quarry layout should:

- Permit efficient excavation and stockpiling of gravel;
- Allow the trucks, tractor and trailers or other haulage vehicles to enter and leave without obstructions;
- Repair the quarry access road, if necessary, to ensure safe passage of haulage vehicles.

At the quarry or borrow pit, the bulldozer or excavation labourers should have stockpiled sufficient gravel for the work. The excavating and stockpiling of gravel should create low, broad heaps to prevent segregation of the coarser material.

Traffic warning signs should be placed at either end of the re-gravelling site. The existing road surface must be graded-off or reshaped by hand to provide a firm regular surface on which to work. Where possible, the edges should be "boxed" to provide lateral support for the new gravel. The graded/reshaped surface should be watered and compacted. The camber should be checked with a camber board and the road level should fall 4 to 6 cm for each one metre width of road (4-6%).
Drainage System

The road drainage system should be checked and repaired if necessary (see Drainage defects and activities), otherwise the performance of the new gravel surface will be affected.

Gravelling operations

When the initial grading/shaping of the road surface is complete, the loader or the quarry labour should start to load the tippers or trailers with gravel for transport to the re-gravelling site.

The supervisor at the quarry should ensure that gravel is taken from the correct stockpiles and that the trucks/trailers are loaded correctly. Tippers or tractor trailers should always circulate continuously between the quarry and the site. Loading resources should be adjusted to try to keep the haulage equipment working continuously. Dumping should start at the far end of the site so that the heaps of gravel do not impede tippers or other haulage vehicles delivering later loads.

- On two lane roads, material should be dumped on one side of the road only;
- Loads should be placed at the correct spacing as instructed by the supervisor, necessary to give the required thickness of gravel over the complete road width after compaction;
- If the road is not closed, material should be dumped on the shoulder, or dumped and spread immediately by labour;
- The tankers or towed bowers should have filled up with water using the pump and then have driven to the site;
- Initially the existing road surface is sprayed with water;
- Spreading of the gravel can start when there is a working length of about 200 metres of dumped material if using a motor or towed grader. If spreading is by labour, the gravel can be spread as soon as it is dumped, or even unloaded by labour if non-tipping haulage equipment is used;

- The material is alternately spread by the grader/labour and watered with the tanker/bowser until its moisture content is correct for compaction;
- The amount of water to be added must be determined by moisture content tests on site or by the supervisor;
- The tankers/bowers circulate continuously between the site and the source of water;
- The new material is now graded or spread by labour to produce a camber of 4 to 6 cm for each one metre width of road (4 to 6 %). Guide pegs and stringlines should be used with labour spreading;
The camber should now be checked with the camber board at approximately 100 metre intervals along the road for machine spreading and every 10 metres if labour is used;
- To use the camber board, place it on its edge across the road with the shorter end pointing towards the centre line. Check the level bubble;
- If it is central, the camber is correct;
- If it is not central, the camber is either too steep or flat and further grading/ manual reshaping, and compaction are required;
- When the correct camber has been achieved, compaction can start using a self-propelled or towed roller, or a pedestrian vibrating roller for labour works;
- Water should not be added during rolling as the material may stick to the wheels or drums;

- Rolling should start at the edge of the road and work towards the middle. The roller should aim to progress from section to section at the same rate as the grader or labour operations;
- Typically about eight passes of the roller will be needed to achieve full compaction;
- It is possible to re-gravel without the use of water and compaction, but it is difficult to achieve satisfactory results, and subsequent gravel material loss from the surface will be faster.
- The watering and compaction help to preserve the investment in the gravel.
Defect
14-01

Paved road pothole or surface defect

<table>
<thead>
<tr>
<th>Development, if neglected</th>
<th>Paved road pothole or surface defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road becomes very rough, slowing and damaging vehicles. Water ponds on road surface, speeding the deterioration and increasing risk of accidents. Road user costs increase substantially. Road may become impassable.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maintenance Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depending on the type of paved road surface:</td>
</tr>
<tr>
<td>14-01A Spot/Pothole Repair (Macadam)</td>
</tr>
<tr>
<td>14-01B Spot/Pothole Repair (Stone setts)</td>
</tr>
<tr>
<td>14-01C Spot/Pothole Repair (Mortared stone)</td>
</tr>
<tr>
<td>14-01D Spot/Pothole Repair (Dressed stone)</td>
</tr>
<tr>
<td>14-01E Spot/Pothole Repair (Emulsion chip seal)</td>
</tr>
<tr>
<td>14-01F Spot/Pothole Repair (Emulsion sand seal)</td>
</tr>
<tr>
<td>14-01G Spot/Pothole Repair (Emulsion gravel/slurry seal)</td>
</tr>
<tr>
<td>14-01H Spot/Pothole Repair (Un-mortared brick)</td>
</tr>
<tr>
<td>14-01i Spot/Pothole Repair (Mortar jointed brick)</td>
</tr>
<tr>
<td>14-01J Spot/Pothole Repair (Non-reinforced concrete)</td>
</tr>
<tr>
<td>14-01K Spot/Pothole Repair (Reinforced concrete)</td>
</tr>
<tr>
<td>14-01L Pothole Reinstatement (cold mix)</td>
</tr>
<tr>
<td>14-01M Pothole (Base Failure Repair)</td>
</tr>
</tbody>
</table>

Although well-constructed, paved roads or sections should give many years of trouble-free service, from time to time defects can be expected to develop in any surface, such as:

- Cracking;
- Rutting;
- Potholes;
- Edge break.
Surfacing defects are normally limited in extent and can be repaired using labour, suitable hand tools and limited materials. Normally only light compaction equipment is required. Any work on the road surface should be signed either side of the repairs to warn road users and for the safety of those carrying out the work. For all of the paved road surface types, the repair techniques are very similar, and consist of:

- Marking out the area to be repaired;
- Excavation of the area to be repaired;
- Backfilling the hole with new material and compacting.

<table>
<thead>
<tr>
<th>Marking out the area to be repaired</th>
<th>The area to be treated is marked out with chalk by drawing a rectangle around the defects.</th>
</tr>
</thead>
</table>
| Excavation of the area to be repaired | It is necessary to:
  - Remove all loose or damaged material from within the marked out area of the road surface back to a firm, sound material. Sledgehammers, crowbars, hammers and chisels may be required;
  - Increase the depth of the hole until firm, dry material is found and then trim the walls of the hole so that they are vertical. If water or excessive moisture is present, then arrangements must be made to drain it away from the pavement foundation;
  - Trim the bottom of the hole such that it is flat, horizontal and free from loose material then compact it with a hand rammer. |
| Backfilling the hole with new material | The repair will depend on the type of surface. Specifications and requirements on each material are contained in the ERA Specifications. The same specifications and standards should be applied to the repair. The hole is filled with a selected material to match the existing surrounding good surface and base materials. This can consist of new material, or in the case of e.g. stone paving, recycled undamaged pieces. The material is placed in the hole and compacted in one or more layers of regular thickness depending on the depth and materials involved. Generally, the last layer, prior to compaction, must have an excess thickness of about 1/5 the depth of the final layer, in order to allow for settlement on compaction. Compaction is continued depending on the size of the excavation, using the vibrating roller, plate compactor or with a hand rammer, until the surface is level. |
Porous repairs will require a seal coat to prevent penetration of water.
### Defect 15-01  
**Road Sign dirty**

**Development, if neglected**
Road users do not benefit from the warning or information intended by the road sign. This is a safety issue and could lead to accidents if not corrected.

**Maintenance Activities**
- **15-01 Cleaning road sign**
  - Clean all dirty signs and remove dirt and dust.

### Defect 16-01  
**Road Sign paint defective**

**Development, if neglected**
Road users do not benefit from the warning or information intended by the road sign. This is a safety issue and could lead to accidents if not corrected.

**Maintenance Activities**
- **16-01 Repainting road sign**
  - Repair corroded, damaged or faded paintwork. Wire brush away any loose material and corrosion. Apply metal primer to bare metal areas. Re-apply paint to the correct specifications, colours, shapes and sizes according to the ERA Sign Standards.

### Defect 16-02  
**Road Sign damaged/missing**

**Development, if neglected**
Road users do not benefit from the warning or information intended by the road sign. This is a safety issue and could lead to accidents if not corrected.

**Maintenance Activities**
- Replace Road Sign
With limited resources, it is usually necessary to set priorities for carrying out maintenance work, which should always take importance over any route upgrading or improvement works. Protect what you have before extending your assets and liabilities!

Furthermore, maintenance is most effective when applied to ‘maintainable’ routes, that is, those with a road camber and drainage system already established. This is preferable to trying to work on un-drained tracks and sunken road sections, which will consume a lot of resources with limited impact with the limited resources available.

The usual questions are:
- Which Route?
- Which maintenance activity?

**Route Priorities**

Within the community, the routes with the higher maintenance priorities should be agreed. For simplicity and clarity, it is best to divide all routes into 2 or 3 priority groups based on the following suggested criteria:

- Strategic inter-community or main road links;
- Is it maintainable? That is, does it already have camber and working drainage system?
- Traffic: high (e.g. more than 25 motor vehicles/day) or low;
- Population served;
- Value of volume of crops extracted each year;
- Serving markets, educational or health facilities.

It is useful to list the routes as an Inventory of assets to be managed, as an aid to planning and management, for example:

**Table G.7.1: Example inventory**

<table>
<thead>
<tr>
<th>Route</th>
<th>Length (km)</th>
<th>Daily traffic in motor vehicles</th>
<th>Reasons for priority</th>
<th>Days impassable last year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Priority A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main road to A</td>
<td>6.0km gravel</td>
<td>65</td>
<td>Main Access</td>
<td>0</td>
</tr>
<tr>
<td>A to Kebele B</td>
<td>3.5km earth with spot paving</td>
<td>50 (April 2015)</td>
<td>School and teff exports</td>
<td>0</td>
</tr>
<tr>
<td><strong>Priority B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A to Kebele C</td>
<td>4.5km earth</td>
<td>20 (January 2015)</td>
<td>Horticultural</td>
<td>2</td>
</tr>
<tr>
<td>Kebele B to C</td>
<td>5.0km earth</td>
<td>12 (October 2014)</td>
<td>Dispensary</td>
<td>5</td>
</tr>
<tr>
<td>Kebele C to D</td>
<td>7.0km earth</td>
<td>&lt;10 (July 2015)</td>
<td>Pottery, sunken sections</td>
<td>15</td>
</tr>
</tbody>
</table>

It is beneficial for this information to be displayed at prominent community locations.
**Maintenance Activity Priorities**

Where it is possible to arrange route maintenance on a number of occasions each year, the following seasonal priorities should be made for each group of maintenance activities:

**BEFORE RAINS:** Drainage

**DURING RAINS:** Drainage & Road Surface unpaved road sections

**AFTER RAINS:** Road Surface paved sections & Roadside activities & Occasional maintenance

In this way the vital road drainage system is prepared for the rainy periods and is kept functioning through the rains. The earth and gravel surfaces are most effectively maintained during the rains where there is moisture in the materials to help consolidate them after reshaping. Paved roads may have minor defects (e.g. small potholes or cracks) which may propagate very fast and become severe during the rains. As a result, the road may become impassable. These defects should be repaired before the rains.

Some variations to these general priorities may be applied due to local conditions.

If a route becomes blocked or totally impassable, this is no longer a maintenance problem. It will usually require the reasons to be investigated and additional resources to be secured to re-open it. Assistance or advice may be required from Regional Road Authorities.

**Upgrading or Spot Improvement Priorities**

Each year an assessment should be made of any desirable spot improvements that should be made if resources are available.
There are a number of ways that maintenance work can be organised depending on the financial and human resources available, and ‘in-house’ and technical capacity of the organising authority.

In practical terms, the maintenance of Low Volume Roads (LVR) will be principally carried out by labour methods with possible occasional support of intermediate or heavy equipment. The last option is usually too expensive to mobilise and inefficient for remote, relatively small scale, rural road works.

The main work organization options are detailed in this section with their typical advantages and disadvantages. The Works Options are:

- **Option 1 - Small Contractor (Private)**;
- **Option 2 - Force Account**;
- **Option 3 - Community or Religious Group**;
- **Option 4 - Length Person or Family Contract**;
- **Option 5 - Compulsory/Voluntary Labour**;
- **Option 6 - Hire-in equipment (in combination with other options)**;
- **Option 7 - Large Contractor Based System**.

**Option 1- Small Contractor (Private)**

The small enterprises will be based in the region or local Weredas. They may be general or building contractors with established contracting experience in earthworks, masonry and concrete skills. They would be expected particularly to make use of local labour, and may have access to light equipment such as a concrete mixer or tractor. This implementation option can be suitable for All Maintenance activities.

**Advantages:**
- Overheads lower than big contractor;
- Low mobilization and demobilization costs;
- Experience of the enterprise;
- Available range of building and maintenance skills;
- Local enterprise committed to the community;
- Good prospects for local employment and money being injected into the community.

**Disadvantages:**
- Time, resources and costs involved with preparing and managing the contract;
- Market for maintenance works currently not developed so prices may be distorted (guideline unit costs should be available from regional authorities);
- Small contractor may have to hire in some equipment;
- May initially require some training/ mentoring, or a higher level of supervision than large contractors;
- May have difficulty in obtaining credit for purchases, or financing cash flow;
- Insufficient funds currently available to pay for this approach for all maintenance work (but may be suitable for selected works – see also Option 6);
- Risks of disputes over interpretation of contract responsibilities.
Option 2 – Force Account
This option makes use of a permanently employed and equipped workforce to carry out the maintenance work such as regional road management units. This implementation option can be suitable for All Maintenance activities.

Advantages:
- Direct response to all maintenance needs;
- Rapid mobilization when funds are available;
- Retain skills and experience within organization, familiarity with the network, standards, work methods;
- Minimum of works documentation requirements;
- Dealings/ disputes with outside parties minimized;

Disadvantages:
- In some cases, no budget or funds are currently available for this option;
- Difficulties in equipment procurement & the lowest initial purchase cost policy can hinder the standardization and efficiency;
- Poor mobility of the workforce around the network unless transport is provided (at considerable cost);
- Paid labour and equipment may be standing if no funds available for works;
- Low efficiency and poor management/use of available resources, poor cost-awareness;
- Little pressure to try new solutions/ technologies;
- High mobilization and demobilization costs if sourced from regional level.

Option 3 – Community Group
The use of a group of persons based within the community and organized specifically to carry out the maintenance works under an agreement or contract with the Wereda authority. This can be for a single route, or a number of routes served by the community. This approach differs from the Length person or Family contract approach only in that the number of persons expected to be involved would be greater, and that consequently work would probably be concentrated at a particular time or times of the year. This implementation option can be particularly suitable for the Regular Maintenance activities

Advantages:
- Low cost compared to most other forms of contract (due to low overheads, low mobilization and demobilization costs, absence of profit component, and by local participation);
- Can be cash or in-kind payment according to community circumstances
- Simple contract/agreement required;
- Direct response to Regular maintenance needs – Rapid mobilization, or planned seasonal inputs;
- Retain skills and experience within the community, familiarity with the network and any problem sections;
- Close control of the works personnel;
- Pride of ‘ownership’ for the network, and appreciation of importance of the asset to the community;
- No dealings/disputes with parties outside of the community;
- Employment and money/resources recycled within the community;
- Employment can be targeted at poor or disadvantaged persons in the community.
Disadvantages:
- Possibly insufficient cash funds available to fully pay for this approach in poor communities;
- Possible difficulties in controlling output and quality;
- Not suitable in areas of dispersed or low population density;
- No equipment capability;
- May not have access to construction quality hand tools;
- Community groups may not have members who are professionals or semi-professionals in the road industry; this may result unprofessional work and failure;
- May initially require some training/mentoring;
- Community groups are usually supported by government for the sake of job creation, and may not comply with all legal procedures; this may lead to problems in the implementation stages.

**Option 4 – Length Person or Family Contract**

A contract or agreement is drawn up for an individual or family to carry out specified routine maintenance activities on a section of road, at certain times of the year, for a payment in cash or in-kind for work on a full or part time basis.

Usually a labourer is appointed for a distinct section of road close to his/ her home, typically 1 to 1.5 km in length. He or she is provided with all the necessary (construction quality) hand tools to carry out all the routine maintenance activities as instructed by the community authority. An advantage is that regular maintenance of the entire road can be arranged at all times and one person can be made fully responsible of a road section. A disadvantage is that supervision has to be mobile and visit frequently to ensure that performance does not deteriorate.

Advantages:
- Low cost compared to most other forms of contract (due to low overheads, low mobilization and demobilization costs, absence of profit component, and by local participation);
- Can be cash or in-kind payment according to community circumstances
- Simple contract/agreement required;
- Flexible approach to seasonal needs. Rapid mobilization;
- Pride of ‘ownership’ for the network;
- No dealings/disputes with parties outside of the community;
- Employment and money/resources recycled within the community;
- Employment can be targeted at poor or disadvantaged persons in the community.

Disadvantages:
- Possibly insufficient cash funds available to fully pay for this approach in poor communities;
- Possible difficulties in controlling output and quality;
- Not suitable in areas of dispersed or low population density;
- No equipment capability;
- May not have access to construction quality hand tools;
- May initially require some training/mentoring;
- System will degenerate if supervisor is not continuously mobile and effective in management;
- There is no guarantee of continuity of the agreement if the person is displaced or moves to another area.
Option 5 – Compulsory/Voluntary Labour

The use of local (community) labour to carry out maintenance works on the roads on a ‘no-fee’ basis is one of the options for maintaining community roads. The approach can be suitable for Regular Maintenance activities. It has been used successfully on LVR and routes without government responsibility. If the whole community can be persuaded to attend a ‘maintenance day’ once or twice a year with their hand tools, there will be sufficient labour resources to carry out the necessary maintenance work under the guidance of a trained supervisor (see estimated input requirements in next chapter). This is the cheapest way to maintain a LVR and involves no taxation, cost or levy to the community. Everybody contributes and benefits equitably. Wealthier inhabitants, traders or other well-wishers could contribute hand tools, equipment hire or food to create a community occasion.

Advantages:
- No financing or cash accounting involved;
- In richer communities, individuals can elect to pay cash instead. This can provide funding for materials, handtools and equipment hire, or even paid labour;
- Minimum of works documentation requirements;
- Direct response to all maintenance needs;
- Rapid mobilization;
- Retain skills & experience within community;
- Direct supervision of works;
- Pride of ‘ownership’ for the network;
- No dealings/disputes with outside parties.

Disadvantages
- All persons contribute equally, whether rich or poor;
- Can be a severe burden on the community’s poorest persons;
- May be difficulty in motivating and organising inputs;
- Difficulties in controlling output and quality;
- Not suitable for work during the agricultural ‘high’ season;
- Not suitable in areas of dispersed or low population density;
- Few prospects for PAID community employment or money being injected into the community;
- No equipment capability;
- May not have access to construction quality hand tools;
- May initially require some supervisor and ‘gang leader’ training/ mentoring.

Option 6 – Hire-in equipment

This is an option to supplement the other options to provide equipment for specific operations such as towed grading or materials haulage. The funding could be provided by the community authority if available, or a benevolent trader, farmer or other well-wisher.

Option 7 – Large Contractor Based System

The employment of a large equipment-based contractor may be considered. They are usually based in Addis Ababa or regional centres and their overall costs due to overheads, mobilization and demobilization costs and profit components would be very high. Therefore, the total costs would be extremely high and unlikely to be affordable by the community. In cases where a contractor is funded externally to construct a road, this contractor may be engaged as part of the contract to maintain the road for some years after the final construction acceptance is finalized.
It is important to plan the maintenance works according to the defect repair needs, the priorities and the resources available to carry out the works.

The following labour resource requirements were developed from research in East Africa and can be used as an outline planning guide.

Table G.9.1: Outline Regular Maintenance Planning for LVRs

<table>
<thead>
<tr>
<th>Number of “wet” months</th>
<th>Number of Person-days of work expected/km/year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gravel &lt;50vpd</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>68</td>
</tr>
<tr>
<td>12</td>
<td>100</td>
</tr>
</tbody>
</table>

Notes:

i. Number of “wet” months per year are with rainfall >25mm.

ii. Estimates assume ‘maintainable’ road with proper camber and drainage system and gradients <6%. Not applicable for problem soils such as ‘black cotton’.

iii. Does not include Occasional works such as re-gravelling.

With good record keeping a similar table can be developed for each community. Equipment inputs may be required for materials haulage and towed grading. Earth and gravel roads require reshaping/grading typically between 1 and 4 times per year. These estimates will help to make resource and cost estimates for each road each year.

Productivity Targets

To plan and manage maintenance works it is useful to have productivity Standards, Norms or Targets. These need to be flexible considering the variable nature of LVR maintenance works, experience of the supervisor and workforce, and whether the work is carried out on a paid or voluntary basis. Development of local Norms or Targets can take considerable time to achieve. The following Targets were developed from research in East Africa and practice in Southern Africa, and can serve as a reference point. The standards were developed under close supervision conditions, with a well trained workforce. They represent the best productivities that can be achieved with a well organised and managed workforce. They should therefore be as targets to be worked towards. It is expected that under normal conditions 60 – 80% of the productivity standards should be achieved. Good record keeping can allow local productivity standards to be developed over time.

Table G.9.2: Productivity Targets

<table>
<thead>
<tr>
<th>PRODUCTIVITY TARGETS PER PERSON-DAY</th>
<th>TASK DIFFICULTY</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODE 1-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAINTENANCE ACTIVITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut grass - light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNIT m/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Wet areas 425</td>
<td>260</td>
</tr>
<tr>
<td>2</td>
<td>Dry areas 310</td>
<td>230</td>
</tr>
<tr>
<td>3</td>
<td>190</td>
<td>170</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Difficulty = Width of grass cutting
1) up to 1.0m
2) 1.0 to 2.0m
3) Over 2.0m
<table>
<thead>
<tr>
<th>CODE</th>
<th>MAINTENANCE ACTIVITY</th>
<th>UNIT</th>
<th>TASK DIFFICULTY</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-01</td>
<td>Cut grass - dense</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>310 240 175 -</td>
<td></td>
</tr>
<tr>
<td>1-02</td>
<td>Bush clearing - light</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>425 260 190 -</td>
<td></td>
</tr>
<tr>
<td>1-02</td>
<td>Bush clearing - dense</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>275 225 175 -</td>
<td></td>
</tr>
<tr>
<td>2-01</td>
<td>Shoulder Rehabilitation (manual)</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100 80 65 -</td>
<td></td>
</tr>
<tr>
<td>3-01</td>
<td>Plant grass and water</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100 80 65 -</td>
<td></td>
</tr>
<tr>
<td>4-01</td>
<td>Culvert Cleaning</td>
<td>As shown</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 culverts/</td>
<td>4 culverts/</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>day</td>
<td>1 culvert/</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>day</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 days/</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>culvert</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 days/</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>culvert</td>
<td></td>
</tr>
<tr>
<td>4-02a</td>
<td>Drain Clearing - Manual (Culvert outfall)</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>55 40 25 -</td>
<td></td>
</tr>
<tr>
<td>4-02a</td>
<td>Drain Clearing - Manual (Turnout drains)</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60 45 30 -</td>
<td></td>
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<td>4-02a</td>
<td>Drain Clearing - Manual (side drains)</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
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<tr>
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<td></td>
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<td>Wet areas 65</td>
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<td>Dry soft soil 55</td>
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<td>Dry hard soil 30</td>
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<td>5-01</td>
<td>Repair Erosion Damage (Selected Fill in</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drains)</td>
<td></td>
<td>1  2  3  4</td>
<td></td>
</tr>
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<td></td>
<td>Wet areas 100</td>
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<td>Dry areas 100</td>
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<td></td>
<td>23 30 -</td>
<td></td>
</tr>
<tr>
<td>6-02</td>
<td>Dry Masonry Repair</td>
<td>m/day</td>
<td>1  2  3  4</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>7 4 - - -</td>
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<tr>
<td>CODE</td>
<td>MAINTENANCE ACTIVITY</td>
<td>UNIT</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------------</td>
<td>------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>8-01</td>
<td>Build wooden/stone scour check</td>
<td>No/day</td>
<td>5</td>
<td>7</td>
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<tr>
<td>9-01</td>
<td>Reshape &amp; Compact Earth Road Camber</td>
<td>route m/day</td>
<td>70</td>
<td>50</td>
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<td>10-01</td>
<td>Spot Repair - Selected Material/Aggregate</td>
<td>Wheel barrows/day</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>10-02</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>11-01</td>
<td>Blade Gravel Road (light)</td>
<td>route km/day</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>12-01</td>
<td>Blade Gravel Road (heavy)</td>
<td>route km/day</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
10. FURTHER ADVICE AND ASSISTANCE

Documentation
The following documents and publications may be accessed for further information. Many of these documents may be accessed or downloaded free of charge from ERA, RECAP or other websites:

1. Ethiopian Road Authority, LVR Design Manual, 2016;
2. Ethiopian Road Authority, Maintenance Technical Specifications, 2003;
3. Ethiopian Road Authority, Intermediate Technology Roadworks Equipment, November 2010;
7. Transport and Road Research Laboratory, Overseas Road Note 7, Volume 2, Bridge Inspector’s Handbook, 1988;
8. World Road Association (PIARC), International Road Maintenance Handbook, 4 Volumes, 1994 and revisions;

Knowledge Sources
1. Knowledge Centre, Ethiopian Roads Authority, Ras Abebe Aregay Street, P O Box 1770 Addis Ababa;
2. RECAP & AFCAP websites: http://www.research4cap.org
3. Transport Research Laboratory (TRL), UK;
4. CSIR, South Africa;
5. Regional Road Authorities.
Abney Level - Small hand held slope measuring and levelling equipment.

Aggregate - Hard mineral elements of construction material mixtures, for example: sand, gravel, crushed rock.

Aggregate Brooming - Using a broom to spread chippings on a surface.

Alligator Cracks - See Crazing.

Apron - The flat invert of the culvert inlet or outlet.

Asphalt - Another word for bitumen. Sometimes used to describe plant mixed bituminous materials.

Asphaltic Concrete - A high quality manufactured mixture of bitumen and aggregates. Expensive and usually only used on main roads.

Attendant or Lengthman - A person contracted or appointed to maintain a section of road. Can be male or female and the term ‘Attendant’ or ‘Lengthman’ assumes either sex.

Basin - A structure at a culvert inlet or outlet to contain turbulence and prevent erosion.

Berm - A low ridge or bund of soil to collect or redirect surface water.

Bituminous Slurry (Slurry-Seal) - Mixture, usually of fine-grained aggregates, water, bituminous binder (emulsion), cement, and sometimes an additive, for a road surface seal.

Bituminous Binder (Asphalt) - A petroleum oil based or natural product used to bind or coat aggregates for road pavements.

Bleeding - Defect: Excess binder on the surface of the pavement.

Blinding -
  a. A layer of lean concrete, usually 5 to 10 cm thick, placed on soil to seal it and provide a clean and level working surface to build the foundations of a wall, or any other structure.
  b. An application of fine material e.g. sand, to fill voids in the surface of a pavement or earthworks layer.

Block Cracking - Defect: Interconnected cracks forming a series of large blocks usually with sharp corners or angles.

Brick (clay) - A hard durable block of material formed from burning (firing) clay at high temperature.

Bridge - A structure usually with a span of 5 metres or more, providing a means of crossing above water, a railway or another obstruction, whether natural or artificial. A bridge consists of abutments, deck and sometimes wingwalls and piers, or may be an arch.

Camber - The road surface is normally shaped to fall away from the centre line to either side. The camber is necessary to shed rain water and reduce the risk of passing vehicles colliding. The slope of the camber is called the crossfall. On sharp bends the road surface should fall directly from the outside of the bend to the inside (superelevation).

Camber Board - Apparatus for checking the crossfall of the road camber, or the shoulder.

Cape Seal - A road surface layer formed by slurry seal laid on top of a bituminous chip seal.

Carriageway - The road pavement or bridge deck surface on which vehicles travel.

Cascade - A drainage channel with a series of steps, sometimes with intermediate silt traps or ponds, to take water down a steep slope.

Catchpit - A manhole or open structure with a sump to collect silt.

Catchwater Drain - See Cutoff.
- **Causeway or Vented Drift** - Low level structure constructed across streams or rivers with openings to permit water to pass below road level. The causeway may become submerged in flood conditions.

- **Check Dams** – (see also Scour Checks) Small checks in a ditch or drain to reduce water velocity and reduce the possibility of erosion.

- **Chippings** - Clean, strong, durable pieces of stone made by crushing or napping rock. The chippings are usually screened to obtain material in a small size range.

- **Chip Seal** - A surface layer formed by stone chippings laid onto a bituminous seal coat.

- **Chute** - An inclined pipe, drain or channel constructed in or on a slope.

- **Cobble Stone (Dressed stone)** - Cubic pieces of stone larger than setts, usually shaped by hand and built into a road surface layer or surface protection.

- **Cofferdam** - A temporary dam built above the ground to give access to an area which is normally, or has a risk of being, submerged or waterlogged. Cofferdams may be constructed of soil, sandbags or sheetpiles.

- **Compaction** - Reduction in bulk of fill or other material by rolling or tamping.

- **Counterfort Drain** - A drain running down a slope and excavated into it. The excavation is partly or completely filled with free draining material to allow ground water to escape.

- **Cracking** - Defect: Narrow breaks in a surfacing or pavement material caused by overloading, fatigue or weakness of the material.

- **Crazing (Alligator Cracks)** - Defect: Interconnecting network of cracks in the road surfacing.

- **Cribwork** - Timber or reinforced concrete beams laid in an interlocking grid, and filled with soil to form a retaining wall.

- **Cut-off/Catchwater Drain** - A drain constructed uphill from a cutting face to intercept surface water flowing towards the road.

- **Debris Rack or Grill** - Grill, grid or post structure located near a culvert entrance to hold back floating debris too large to pass through the culvert.

- **Deck** - The part of a bridge that spans between abutments or pier supports, and carries the road traffic.

- **Depression** - Defect: Localised low areas of limited size in the pavement surface or in any other surface.

- **Ditch (Open Drain)** - A long narrow excavation designed or intended to collect and drain off surface water.

- **Drag** - An apparatus towed behind a vehicle or piece of equipment to remove minor irregularities and redistribute loose surface material.

- **Drainage** - Interception and removal of ground water and surface water by artificial or natural means.

- **Drainage Pipe** - An underground pipe to carry water.

- **Dressed Stone** - See Cobble Stone.

- **Drift or Ford** - A stream or river crossing at bed level over which the stream or river water can flow.

- **Earth Road** - See ENS.

- **Edge Cracking** - Defect: Longitudinal cracking near the edge of the pavement.

- **Embankment** - Constructed earthworks below the pavement raising the road above the surrounding natural ground level.

- **ENS (Engineered Natural Surface)** - An earth road built from the soil in place at the road location, and provided with a camber and drainage system.
- **Excess Aggregate** - Defect: Aggregate particles not coated with binder after application of binder.
- **Flow Spreader** - A structure designed to disperse the flow at the outfall of a ditch or drain to minimise the risk of erosion downstream.
- **Fog Seal** - A very light film of binder sprayed onto a road to bind or enrich the surface.
- **Ford** - See Drift
- **Formation** - The shaped surface of the earthworks, or subgrade, before constructing the pavement layers.
- **Fretting** - Defect: The loss of chippings from the surface seal or premix layer due to poor bond between the aggregate and the seal or binder.
- **Gabion** - Stone-filled wire or steel mesh cage. Gabions are often used as retaining walls or river bank scour protection structures.
- **Glazing** - Defect: Wear or embedment of chippings in the surfacing giving a smooth, shiny appearance.
- **Hand Packed Stone** - A layer of large, angular broken stones laid by hand with smaller stones or gravel rammed into the spaces between stones to form a road surface layer.
- **Incremental paving** - Road surface comprising small blocks such as shaped stone (setts) or bricks, jointed with sand or mortar.
- **Invert** - The lowest point of the internal cross-section of a drain or culvert.
- **Layby** - An area adjacent to the road for the temporary parking of vehicles.
- **Lengthman** - See Attendant.
- **Loss of Surface Aggregate** - Defect: Removal of aggregate from a surface dressing, or from surfacings with coated aggregate, or concrete.
- **Macadam** - A mixture of broken or crushed stone of various sizes (usually less than 3cm) laid to form a road surface layer.
- **Manhole** - Accessible pit with a cover forming part of the drainage system and permitting inspection and maintenance of underground drainage pipes.
- **Margins** - The right of way or land area maintained or owned by the road authority.
- **Mitre Drain (Turn Out Drain)** - leads water away from the Side Drains to the adjoining land.
- **Occasional Maintenance** - Operations that are occasionally required on a section of road after a period of a number of years.
- **Open Drain (Ditch)** - A long narrow excavation designed or intended to collect and drain off surface water.
- **Otta Seal** - A surface layer formed by rolling natural gravel into a soft bituminous seal coat.
- **Outfall** - Discharge end of a drain or culvert.
- **Parapet** - The protective edge, barrier, wall or railing at the edge of a bridge deck.
- **Pass** - A single longitudinal traverse made by a grader, roller or other piece of equipment working on the road.
- **Patching** - The execution of minor local repairs to the pavement and shoulders.
- **Pavé** - See Sett
- **Paved Road** - For the purpose of this Manual, a paved road is a road with a Stone, Bituminous, Brick or Concrete surfacing.
- **Pavement** - The constructed layers of the road on which the vehicles travel.
**Permeable Soils** - Soils through which water will drain easily e.g. sandy soils. Clays are generally impermeable except when cracked or fissured (e.g. ‘Black Cotton’ soil in dry weather).

**Plumbing** - Using a calibrated line, with a weight attached to the bottom, to measure the depth of water (e.g. for checking erosion by a structure).

**Profile** - An adjustable board attached to a ranging rod for setting out.

**Ravelling** - The removal/liberation of chippings/gravel/aggregate from the wearing surface due to traffic or poor bond between the aggregate and the binder.

**Regular Maintenance** - Operations required to be carried out once or more per year on a section of road. These operations are typically small scale or simple, but widely dispersed, and require unskilled or trained manpower.

**Reinforced Concrete** - A mixture of coarse and fine stone aggregate bound with cement and water and reinforced with steel roads for added strength.

**Riprap** - Stones, usually between 5 to 50 kg, used to protect the banks or bed of a river or watercourse from scour.

**Road Base and Subbase** - Pavement courses between surfacing and subgrade.

**Road Maintenance** - Suitable regular and occasional activities to keep pavement, shoulders, slopes, drainage facilities and all other structures and property within the road margins as near as possible to their as constructed or renewed condition. Maintenance includes minor repairs and improvements to eliminate the cause of defects and avoid excessive repetition of maintenance efforts.

**Roadway** - The portion within the road margins, including shoulders, for vehicular use.

**Sanding** - Spreading coarse sand onto a bituminous road surface that is bleeding.

**Sand Seal** - A surface layer formed by sand laid onto a bituminous seal coat.

**Scarifying** - The systematic disruption and loosening of the top of a road or layer surface by mechanical or other means.

**Scour** - Defect: Erosion of a channel bed area by water in motion, producing a deepening or widening of the channel.

**Scour Checks** – (see also Check Dams) Small checks in a ditch or drain to reduce water velocity and reduce the possibility of erosion.

**Scuppers** - Drainage pipes or outlets in a bridge deck.

**Sett (Pavé)** - A small piece of hard stone trimmed by hand to a size of about 10cm cube used as a paving unit.

**Shoulder** - Paved or unpaved part of the roadway next to the outer edge of the pavement. The shoulder provides side support for the pavement and allows vehicles to stop or pass in an emergency.

**Slip** - Defect: Slope material sliding downhill because of instability, water penetration or flow.

**Slope** - A natural or artificially constructed soil surface at an angle to the horizontal.

**Slot** - A sample cross section of the road or drain constructed as a guide for following earthworks or reshaping.

**Slurry Seal** - A mixture usually containing fine graded aggregates, water; bitumen emulsion, cement and sometimes an additive, spread on the road surface by a specially equipped machine, or by hand.

**Sods** - Turf but with more soil attached (usually more than 10 cm).

**Soffit** - The highest point in the internal cross-section of a culvert, or the underside of a bridge deck.
- **Special Maintenance** - Certain serious, unforeseen situations necessitating remedial action to be taken as soon as possible, e.g. flood damage, major slips. Consult the regional authorities regarding these.

- **Spray Lance** - Apparatus permitting hand-application of bituminous binder at a desired rate of spread through a nozzle.

- **Squeegee** - A small wooden or metal board with a handle for spreading bituminous mixtures by hand.

- **Streaking** - Defect: Alternate lean and heavy lines of bitumen running parallel to the pavement centre line, caused by blocked or incorrectly set spray nozzles.

- **Stringer** - Longitudinal beam in a bridge deck or structure.

- **Stripping** - Defect: The removal of binder/bitumen due to poor bond between the aggregate and bitumen or presence of moisture.

- **Subbase** - See Road Base.

- **Subgrade** - Upper layer of the natural or imported soil (free of unsuitable material) which supports the pavement.

- **Sub-Soil Drainage** - See Underdrainage.

- **Surface Dressing** - A sprayed or hand applied film of bitumen followed by the application of a layer of stone chippings, which is then rolled.

- **Surface Treatment** - Construction of a protective surface layer e.g. by spray application of a bituminous binder, blinded with coated or uncoated aggregate.

- **Surfacing** - Top layer of the pavement. Consists of wearing course, and sometimes a base course or binder course.

- **Tar Binder** - A binder made from processing coal.

- **Template** - A thin board or timber pattern used to check the shape of an excavation.

- **Traffic Lane** - The portion of the carriageway usually defined by road markings for the movement of a single line of vehicles.

- **Transverse Joint** - Joint normal to, or at an angle to, the road centre line.

- **Traveller** - A rod or pole of fixed length (e.g. 1 metre) used for sighting between profile boards for setting out levels and grades.

- **Turf** - A grass turf is formed by excavating an area of live grass and lifting the grass complete with about 5 cm of topsoil and roots still attached.

- **Turn Out Drain** - See Mitre Drain.

- **Underdrainage (Sub-Soil Drainage)** - System of pervious pipes or free draining material, designed to collect and carry water in the ground.

- **Unpaved Road** - For the purpose of this Manual an unpaved road is a road with a soil or gravel surface.

- **Vented Drift** - See Causeway.

- **Weephole** - Opening provided in retaining walls or bridge abutments to permit drainage of water in the filter layer or soil layer behind the structure. They prevent water pressure building up behind the structure.

- **Windrow** - A ridge of material formed by the spillage from the end of the machine blade or continuous heap of material formed by labour.
- **Wingwall** - Retaining wall at a bridge abutment to retain and protect the embankment fill behind the abutment.
- **2WD** - Two Wheel Drive vehicle or equipment.
- **4WD** - Four Wheel Drive vehicle or equipment.
12. General Requirements

Cross drainage structures usually account for a high proportion of the total investment cost of a road. They are the potential weak points in a Low Volume Road network due to the possible damaging effects of floods and high water flows being concentrated at the points where the water crosses the road. The failure of these structures would result in high replacement costs and long delays due to the closure of the road. It is particularly important therefore, that sufficient attention is given to structures to ensure that they are maintained in good condition.

A culvert, bridge or other structure is an integral part of the road, and its condition will affect the level of service that the road provides. A structure should be designed so that no major repair works should be required during its ‘design life’ (e.g. replacement of abutments, piers or deck structural members). Eventually major works may be required such as a complete new timber bridge deck or safety barrier replacement. However, the structure should be designed to provide many years of service through its design life with only minor maintenance.

Importantly, if the maintenance is not carried out, there can be serious consequences for road users. It can result in increased safety hazards, reduced quality of service or even loss of the structure and severing of the transport link.

It is usually not possible to devise a ‘maintenance-free structure’ for a watercourse crossing at affordable cost. However, application of the Design and Construction guidelines contained in this LVR Manual series should reduce maintenance requirements to an acceptable and manageable level. Conversely, poor design or construction will result in an abnormally high requirement for maintenance, or even eventual loss of the structure.

There are a number of aspects which should be appreciated in devising appropriate management and maintenance arrangements for structures. This applies to consideration of an individual structure, or a large number constructed at various locations on a road network.

Structures will often need no maintenance for periods of many months or sometimes even years. Deterioration or damage to a structure can progress slowly (e.g. corrosion, attack by insects), or suddenly (e.g. in a flood or vehicle accident). The need for repairs may not be obvious to road users or through casual observation from the road. However, the deterioration can progress, if not checked, to result in the need for major works at great cost and requiring substantial unplanned resource mobilisation.

The resources for maintenance and repair of a typical structure are required intermittently, not continuously. It is usually most efficient to provide maintenance resources only when the structure requires maintenance or repair works.

It is important to ensure the maintenance of a structure so that it remains in its intended condition, providing the service and benefits to road users and the community that it was designed for. It is an asset that needs to be managed.

Managing the Structures

The maintenance works required to be carried out on a structure will range from basic seasonal clearing of silt and debris to ensure it continues to function properly, through to replacement of components of the structure when they are worn out or damaged. It can be expected that all structures will normally require at least some basic maintenance each year.

It is necessary to set up a management system to ensure that the structure stays in a condition that it is able to carry out its function in a safe manner. In essence this ‘system’ should identify when work needs to be carried out. From this assessment the maintenance funding and works can be arranged and supervised to ensure that the maintenance is completed satisfactorily.

A system of inspections is required to identify any damage or deterioration of the structure, or problems adjacent to the structure which may threaten its stability.
The key components of a structures management system are:

- An inventory of all structures (i.e. What is the asset? What are its key features? These are management records which generally do not change with time, except for new structures or after major structural changes to an existing one);
- An inspection system (to determine the condition and repair needs);
- Arrangements for specifying, arranging, supervising, recording/reporting and paying for the works. Arrangements should also be in place for checking the ‘value for money’ of maintenance operations and expenditures.

TRL Overseas Road Note 7 provides comprehensive guidelines on the inspection and documentation of inventory and condition information on structures. A paper based system is quite adequate. Computer systems can help if the number of structures being managed is substantial and the operating environment can support the maintenance of the computer system itself, including arrangements for the ongoing costs and skilled resources required. In a limited resource environment, it can be difficult to justify and secure the recurring costs of administration, computer support personnel and inevitable software and hardware upgrades required for a computer system, i.e. there can be an undue and unnecessary dependence on external resources.

Certain maintenance activities such as de-silting and removal of debris should be carried out under a regular programme of works in conjunction with the road maintenance. For example, before the rainy season all silt should be removed from culverts, their inlets and outlet channels. After the rains, and particularly after individual floods, silt and debris should be cleared from structures to avoid later damage due to blockages or diversion/concentration of water.

These regular clearing operations are an ideal opportunity to carry out an inspection of a structure. With the scarcity and expense of engineering personnel, it is possible to train persons with limited education (e.g. the gang leader) to carry out inspections and to alert engineering staff to situations that require their action.

Inspections of all structures should be carried out after a flood situation as this is the most likely time for damage to have occurred. Particular attention should be paid to identifying any movement, especially at joints, cracking/spalling and assessing whether erosion has occurred around abutments and piers, or at the ends of aprons. Where water is permanently standing against the structure, probing with ranging rods, poles or plumb lines should be carried out to identify unseen scouring. A boat or raft may be required for this inspection.

All structures, from culverts to bridges, should receive a documented routine inspection at least once each year. As indicated above these can be carried out by relatively unskilled personnel if the appropriate training is provided. Inspection records should be carefully filed for future reference. Even a report of ‘no defects’ is important management information.

The management of a structure costs money and, even before a structure is built, the ongoing provision of the funds and resources for the management (including inspections) as well as the maintenance of the structure should be assured.

### 12.2 Maintaining the Structure

Structure maintenance activities can be grouped into regular or routine maintenance (Table A1.1), and periodic major operations (Table A1.2).
### Table G.12.1: Structure – Regular/Routine

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning/clearing</td>
</tr>
<tr>
<td>Sweeping</td>
</tr>
<tr>
<td>De-silting</td>
</tr>
<tr>
<td>Unblocking</td>
</tr>
<tr>
<td>Removal of vegetation and flood/wind borne debris (This includes inlets and outlet channels as well as culvert openings themselves)</td>
</tr>
<tr>
<td>Repair of loose/missing connectors and fixings</td>
</tr>
<tr>
<td>Replacement of damaged/missing planks or kerbs</td>
</tr>
<tr>
<td>Painting</td>
</tr>
<tr>
<td>Wood preservation</td>
</tr>
<tr>
<td>Pointing/repair of masonry</td>
</tr>
<tr>
<td>Repair of parapets, marker posts, safety barriers and features/signs</td>
</tr>
</tbody>
</table>

### Table G.12.2: Structure – Periodic

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random stone filling</td>
</tr>
<tr>
<td>Retaining wall repairs</td>
</tr>
<tr>
<td>Riverbed scour repairs</td>
</tr>
<tr>
<td>Gabion repairs</td>
</tr>
<tr>
<td>Structural repairs to the following defects:</td>
</tr>
<tr>
<td>- Structural timber decay, splitting or insect attack</td>
</tr>
<tr>
<td>- Bulging masonry</td>
</tr>
<tr>
<td>- Cracked concrete or masonry</td>
</tr>
<tr>
<td>- Honeycombed concrete</td>
</tr>
<tr>
<td>- Spalling concrete</td>
</tr>
<tr>
<td>- Serious rust or chemical stains</td>
</tr>
<tr>
<td>- Exposed or corroding reinforcement or pre-stressing steel</td>
</tr>
<tr>
<td>- Damp patches on the concrete</td>
</tr>
<tr>
<td>- Seriously corroded structural steelwork</td>
</tr>
<tr>
<td>- Damaged/distorted structural steelwork</td>
</tr>
<tr>
<td>- Loose structural rivets, bolts or other fixings</td>
</tr>
<tr>
<td>- Cracks in structural steelwork</td>
</tr>
<tr>
<td>- Settlement of deck, piers, abutments or wingwalls</td>
</tr>
<tr>
<td>- Expansion joint or bearing defects</td>
</tr>
<tr>
<td>- Erosion requiring piling works</td>
</tr>
</tbody>
</table>

Major repairs will generally require technical expertise for the design and supervision of remedial work. Maintenance works should be planned, organised and supervised using the guidelines set out in the LVR Construction Manual. Maintenance records should be kept for each structure, which include:

- Estimates of work proposed;
- Details of work carried out;
- Date of completion of the repair;
- Supervisor’s quality control reports;
- Actual costs of repair.
Storage of information should be on a structure by structure basis so that the complete history can be easily viewed.

Further guidance on maintaining structures is provided in the PIARC International Road Maintenance Handbook, Volume 4. The handbook includes advice on the defects, resources and maintenance methods involved.

12.3 Common Structures Maintenance Requirements

Damage due to scour and erosion is the most likely cause of major or unrepairable damage to a structure. Once scour or erosion around a structure starts, the damage can increase very rapidly. It is therefore essential that maintenance is carried out promptly to prevent further structural damage.

12.3.1 Drifts

The drift must maintain a firm roadway across the width of the river, which is not covered by debris or eroded by the flood water. The face of the river embankments should also be protected against scour and erosion. It may be possible to encourage the growth of vegetation along the banks to improve the bank stability and prevent erosion. The common maintenance issues to address are:

- Cracking of the slab;
- Undercutting on the downstream side;
- Erosion at ends of slab where it is not extended above high flood levels;
- Lack of downstream protection;
- Guidestones knocked off.

12.3.2 Culverts

The most common maintenance problem associated with culverts is blockage due to silt and other debris. Hence regular cleaning of the culverts is essential as illustrated in Plate A1.1. A blocked culvert can result in damage to the road in 3 ways:

- Water can seep into the subgrade of the road and reduce its strength. The road will tend to subside and the road surface will break up.
- The water can undermine the head and wingwall of the culvert causing it to collapse. The road embankment will then be unsupported and rapidly subside.
- In an extreme case the water level may continue to increase until the water floods over the road. The road may then become impassable and major damage occur as the water erodes the road and culvert. Ultimately the road will be washed away and a large gully will be scoured across the road.

Water discharging from culverts with excessive velocity will erode the stream bed and possibly undermine the whole structure. It is therefore essential to provide some form of protection to the beds immediately below the outlet of a culvert. The protection is usually in the form of a masonry or gabion apron. It may also be necessary to prevent erosion of the watercourse itself further downstream of the culvert. Bio-engineering planting may be an appropriate and low-cost solution.
Plate G.12.1: Culvert Cleaning

The main cause of blockage of culverts is by water carried debris and vegetation (Plate A1.2). Larger debris tends to collect at the entrance to the culvert causing blockage at the headwall, while silt is deposited in and upstream from the culvert. If unchecked this silt can build up until it fills the culvert opening. Long grass at the outlet of a culvert can cause silting at the outlet and eventual blockage of the culvert. It is therefore necessary, particularly before the rainy season, to clean culvert barrels, inlets and outlets to allow water to flow freely through the culvert.

Plate G.12.2: Box Culvert Partially Blocked by Vegetation

Any material removed from a culvert should be disposed of downstream of the culvert to prevent it washing back into the structure. Other common defects that require maintenance to be carried out on culverts include:

- Downstream erosion;
- Headwall knocked down or damaged;
- Outfall channel eroded or silted;
- Undercutting of the culvert outfall apron;
- Ponding of water at the inlet and/or outlet causing subsidence of the road embankment.
12.3.3 Vented Drifts and Large Bore Culverts

The common maintenance requirements with vented fords and large bore culverts are similar to culverts and drifts (Plate A1.3). In addition to the issues discussed above the following defects may need to be corrected during maintenance:

- floating debris, such as tree branches, can block the culvert barrels;
- cracking and breaking of roadway slab;
- cracking and breaking of structure faces.

Plate G.12.3: Cleaning the Drop Inlet and Barrel of a Large Bore Culvert

12.4 Bridge Maintenance

The substantially larger investment in bridges, compared to smaller structures, justifies greater attention to inspection and maintenance of these vital road components. The consequences of failure due to lack of maintenance can be routes being severed for considerable periods with serious adverse social and economic outcomes. It is therefore important to establish a regime of regular bridge inspections and active maintenance response works.

Inspections should be formulated on a regular basis to identify and initiate maintenance repairs for the following possible defects:

- **Minor Defects (non-structural)**
  - Accumulation of dirt or soil on bridge deck;
  - Blocked scuppers;
  - Stones, soil or dirt in joints or around bearings;
  - Vegetation or soil in weep holes or in backfill drainage outlets;
  - Flood debris at or under bridge;
  - Wind-blown debris on or under bridge.

- **Minor Defects (structural)**
  - Loose or missing nailed/bolted connectors or fixings;
  - Damaged running boards or deck planks;
• Rusty steel, faded paint;
• Untreated wood;
• Defective masonry joints.

- Minor Defects (Safety)
  • Damaged safety barrier or parapet;
  • Damaged warning signs.

The following defects may require major repair works and specialist expertise to ensure appropriate remedial works. The inspection system should initiate mobilisation of the necessary expertise when these defects are identified:

- Major Defects
  • Scour adjacent to structure;
  • Structural timber decay, splitting or insect attack;
  • Bulging masonry;
  • Cracked concrete or masonry;
  • Honeycombed concrete;
  • Spalling concrete;
  • Serious rust or chemical stains;
  • Exposed or corroding reinforcement;
  • Damp patches on the concrete;
  • Seriously corroded structural steelwork;
  • Damage/distorted structural steelwork;
  • Loose structural rivets, bolts or other fixings;
  • Cracks in structural steelwork;
  • Settlement of deck, piers or abutments;
  • Erosion requiring piling works;
  • Vehicle Impact damage (particularly to steel panel bridges).

Plate G.12.4: Serious Vehicle Impact Damage to Steel Panel Bridge

Further guidance on bridge and structures maintenance is available from the PIARC International Road Maintenance Handbook Volume IV.
## APPENDIX G.2: SPECIFICATIONS FOR MAINTENANCE OF LOW VOLUME ROADS

### 13. CODING & MEASUREMENT SYSTEM

Each Defect has a corresponding Maintenance Activity with the same Code. The measurement of each item shall include for full compensation, for labour, materials, tools, supervision, equipment or transport and incidental costs required to carry out the work. Measurement will be by the units shown.

**Table G.13.1: Maintenance Codes**

<table>
<thead>
<tr>
<th>DEFECT CODE</th>
<th>ACTIVITY</th>
<th>MEASUREMENT UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-01a</td>
<td>Grass Cutting (Manual) &amp; Removal of litter</td>
<td>m²</td>
</tr>
<tr>
<td>1-01b</td>
<td>Grass Cutting (Equipment)</td>
<td>m²</td>
</tr>
<tr>
<td>1-02</td>
<td>Bush Clearing</td>
<td>m²</td>
</tr>
<tr>
<td>2-01</td>
<td>Shoulder Rehabilitation (manual)</td>
<td>m²</td>
</tr>
<tr>
<td>2-02</td>
<td>Shoulder rehabilitation (mechanised)</td>
<td>m²</td>
</tr>
<tr>
<td>2-03</td>
<td>Shoulder Blading (mechanised)</td>
<td>m²</td>
</tr>
<tr>
<td>3-01</td>
<td>Plant grass and water it</td>
<td>m²</td>
</tr>
<tr>
<td>4-01</td>
<td>Culvert/Drift Cleaning</td>
<td>No.</td>
</tr>
<tr>
<td>4-02a</td>
<td>Drain cleaning (manual)</td>
<td>m</td>
</tr>
<tr>
<td>4-02b</td>
<td>Drain cleaning (mechanised)</td>
<td>m</td>
</tr>
<tr>
<td>5-01</td>
<td>Repair erosion Damage (selected fill)</td>
<td>m³</td>
</tr>
<tr>
<td>5-02a</td>
<td>Repair erosion Damage (rock fill)</td>
<td>m³</td>
</tr>
<tr>
<td>5-02b</td>
<td>Terracing and Wattling</td>
<td>m²</td>
</tr>
<tr>
<td>6-01</td>
<td>Mortared masonry repair</td>
<td>m³</td>
</tr>
<tr>
<td>6-02</td>
<td>Dry masonry repair</td>
<td>m³</td>
</tr>
<tr>
<td>7-01</td>
<td>Gabion structure repair</td>
<td>m³</td>
</tr>
<tr>
<td>8-01</td>
<td>Build stone/wooden scour checks</td>
<td>No.</td>
</tr>
<tr>
<td>9-01</td>
<td>Re shape and compact earth road camber</td>
<td>m²</td>
</tr>
<tr>
<td>10-01</td>
<td>Spot repair selected material</td>
<td>m³</td>
</tr>
<tr>
<td>10-02</td>
<td>Spot repair crushed aggregate</td>
<td>m³</td>
</tr>
<tr>
<td>11-01</td>
<td>Blade gravel road (light)</td>
<td>Carriageway m</td>
</tr>
<tr>
<td>12-01</td>
<td>Blade gravel road (heavy)</td>
<td>Carriageway m</td>
</tr>
<tr>
<td>13-01</td>
<td>Gravel re-surfacing (selected material)</td>
<td>m³</td>
</tr>
<tr>
<td>14-01a</td>
<td>Spot pothole repair (Macadam)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01b</td>
<td>Spot pothole repair (Stone setts)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01c</td>
<td>Spot pothole repair (Mortared stone)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01d</td>
<td>Spot pothole repair (Dressed stone)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01e</td>
<td>Spot pothole repair (Emulsion chip seal)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01f</td>
<td>Spot pothole repair (Emulsion sand seal)</td>
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</tr>
<tr>
<td>14-01g</td>
<td>Spot pothole repair (Emulsion gravel/slurry seal)</td>
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</tr>
<tr>
<td>14-01h</td>
<td>Spot pothole repair (Un-mortared brick)</td>
<td>m²</td>
</tr>
</tbody>
</table>
### Part G: Road Maintenance

<table>
<thead>
<tr>
<th>DEFECT CODE</th>
<th>ACTIVITY</th>
<th>MEASUREMENT UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-01i</td>
<td>Spot / pothole repair (Mortared brick)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01j</td>
<td>Spot / pothole repair (Non-reinforced concrete)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01k</td>
<td>Spot / pothole repair (Reinforced concrete)</td>
<td>m²</td>
</tr>
<tr>
<td>14-01l</td>
<td>Spot / pothole repair (Cold mix)</td>
<td>m³</td>
</tr>
<tr>
<td>14-01m</td>
<td>Pothole (Base failure repair)</td>
<td>m³</td>
</tr>
<tr>
<td>15-01</td>
<td>Cleaning road sign</td>
<td>No.</td>
</tr>
<tr>
<td>16-01</td>
<td>Repainting road sign</td>
<td>No.</td>
</tr>
<tr>
<td>16-02</td>
<td>Replace road sign</td>
<td>No.</td>
</tr>
</tbody>
</table>

### Roadside Activities

<table>
<thead>
<tr>
<th>DEFECT 1-01a</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grass Cutting (Manual) &amp; Removal of litter m²</td>
</tr>
</tbody>
</table>

**Scope of works:** Cutting of grass and shrubs along the roadside to improve visibility along the road, on curves and to avoid obstruction of road signs, or concealing stray animals or pedestrians near or crossing the road.

**Specifications:**
- Place warning signs and safety devices
- Cut all grass evenly to a height of a maximum of 150mm above the ground level and to the required width from the edge of the road
- Grass shall generally be cut while facing the road so that any flying objects due to the slashing are not thrown onto the carriageway
- Clear all cut grass, from the road carriageway, drains ditch and from inlets and outlets of drainage structures and dispose in a safe place away from the road
- Collect and safely dispose of any litter or debris on the roadside
- **DO NOT BURN** the grass cut along the road or the debris removed after maintenance
- Measure and record the total length and width of road side cut
- Remove the temporary signs and safety devices.

<table>
<thead>
<tr>
<th>DEFECT 1-01b</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grass Cutting (Equipment)</td>
</tr>
</tbody>
</table>

**Specifications:**
- Place warning signs and safety devices
- Cut grass to a maximum height of 150mm
- Mow grass using tractor drawn mower or hand held sickle power mower to level ground free from obstruction from debris
- Workmen to work behind the mower to cut grass in ditches, and areas round fixed road furniture
- Rake and load onto trailer/truck to designated disposal sites. **BURNING OF GRASS** in not allowed
- Clear the carriageway, drains, mitre drains, inlet and outlet of drainage structures of any debris and litter and dispose of safely
- Measure and record total length and width of road side mowed
- Remove all temporary signs and safety devices.

**Description of bill item:**
1-01: Unit of measurement shall be in m² of area of grass cut.
## Defect 1-02

**Activity:** Bush Clearing m²

**Scope of works:** Improve visibility to maintain safe sight distance, visibility of road signs, road markers, animals and pedestrians within the road reserve.

**Specifications:**
- Place warning signs and safety devices
- Cut, uproot and remove bushes to ensure that all bushes are cleared
- Workmen must ensure that no damage is caused to fixed objects such as road furniture when removing debris and cut or uprooted during clearing
- Backfill and compact to density of surrounding ground all excavated holes dug during removal of roots
- Collect and clear all cut roots and debris from drains, carriageway and road reserve, load and dispose to designated sites
- Measure and record the length and width of area cleared
- Remove temporary road signs and safety devices.

**Description of bill item:**
1-02: Clearing of bush, shrubs and roots on the side of the road to improve visibility and road safety. Unit of measurement shall be in m² of area of bush cleared.

## Defect 2-01

**Activity:** Shoulder rehabilitation (manual) m²

**Scope of works:** Repair of erosion damage to restore efficient drainage and improve road safety.

**Specifications:**
- Place warning signs and safety devices
- Mark areas to be repaired by indenting on the ground eroded areas
- Scarify with a pick, shovel hoe etc. to depth of minimum 100mm
- Moisten the area if material is dry
- Add material of similar composition/specification if required to the existing and add water to obtain optimum moisture content
- Spread the material to the correct cross fall to ensure good drainage
- Compact material to a density specified by the Engineer
- Check that the finished cross fall complies with the Specification requirements
- Measure and record the area repaired and volume of gravel/material used
- Tidy up the area and remove temporary signs and safety devices.

**Description of bill item:**
2-01: Repair of erosion damage to restore efficient drainage and improve road safety. Unit of measurement shall be in m² of shoulder/slope area repaired.
### DEFECT 2-02

<table>
<thead>
<tr>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Rehabilitation (mechanised) m²</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair major erosion damages on road shoulder and slopes.

**Specifications:**
- Place warning signs and safety devices
- Mark areas to be repaired by indenting on the ground eroded areas
- Scarify with a pick, shovel hoe etc. to depth of minimum 100mm
- Moisten the area if material is dry
- Add material of similar composition/specification if required to the existing and add water to obtain optimum moisture content
- Spread the material to the correct cross fall to ensure good drainage
- Compact material to a density specified by the Engineer
- Check that the finished cross fall complies with the Specification requirements
- Measure and record the area repaired and volume of gravel/material used
- Tidy up the area and remove temporary signs and safety devices.

**Description of bill item:**
2-02: Repair of erosion damage to restore efficient drainage and improve road safety. Unit of measurement shall be in m² of shoulder/slope area repaired.

### DEFECT 2-03

<table>
<thead>
<tr>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder Blading (mechanised) m²</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of erosion damage to restore efficient drainage and improve road safety.

**Specifications:**
- Place **warning** signs and safety devices
- Mark areas to be repaired by indenting on the ground eroded areas
- Scarify using a towed grader or other authorised equipment, if necessary
- Moisten the area if material is dry
- Spread the material to the correct cross fall to ensure good drainage
- Measure and record the area repaired
- Tidy up the area and remove temporary signs and safety devices.

**Description of bill item:**
2-03: Repair of erosion damage to restore efficient drainage and improve road safety. Unit of measurement shall be in m² area repaired.
### DEFECT 3-01

<table>
<thead>
<tr>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant grass and water it m²</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair slope erosion damage and address cause of the problem before planting grass.

**Specifications:**
- Place warning signs and safety devices
- Mark areas to be repaired
- Add material of similar composition/specification if required to the existing and add water to obtain optimum moisture content
- Import top soil if necessary to improve quality of in situ material

**a Seeding**
- Loosen the soil to a depth of 10 cm in the area to be seeded using rakes or similar tools
- Spread the topsoil to a depth of at least 5 cm
- Apply fertiliser at the specified rate, if directed
- Apply ground limestone at the specified rate and mix in, if directed
- Apply seeds by hand at the specified rate
- Lightly roll the seeded area within 24 hours using hand roller, only if the soil does not adhere to the roller
- The seeded area should be watered as required until the grass has taken hold.

**b Seedlings/Turfing**
- Trim the grass to be planted into slips of 20 to 30 cm and plant them in the V ditch with edge of ditch line slightly uphill forming a U shape.
- Water immediately after planting
- Space the slips 10 to 15 cm apart
- Spacing of the lines of seedlings should not exceed 0.5 m
- Clear the site of left over plants and trimmings
- Measure and record area planted
- Remove temporary signs and safety devices.

**Description of bill item:**
3-01: Repair slope erosion damage and address cause of the problem before planting grass. Unit of measurement shall be in m² area planted with grass.
### DRANAGE ACTIVITIES

<table>
<thead>
<tr>
<th>DEFECT 4-01</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Culvert/Drift Cleaning No</td>
</tr>
</tbody>
</table>

Scope of works: Removal of silt, debris or excess vegetation blocking or interfering with the smooth flow of water into, through and out of drainage structures.

**Specifications:**
- Place warning signs and safety devices
- Culvert to be cleared of all silt and debris. Culvert inlets and outlets to be cleared of vegetation and silt to a width of 2m on both sides of the culvert
- The inlet and outlet trenches to have a bottom width of 400mm more than the culvert diameter, and the trench sides to have a slope of 1:1, or flatter in fine sandy type material
- Material and debris from the culvert/drift must be spread or dumped where they cannot wash back into the watercourse and cause an obstruction to water flow, preferably on the downstream side of the culvert, well away from the watercourse
- Remove temporary signs and safety devices.

**Description of bill item:**
4-01: Removal of silt, debris or excess vegetation blocking drainage structure. Unit of measurement shall be number of culverts/drifts cleaned.

<table>
<thead>
<tr>
<th>DEFECT 4-02a</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drain cleaning (manual) m</td>
</tr>
</tbody>
</table>

Scope of works: Clear drains of all obstacles interfering with flow of water.

**Specifications:**
- Place warning signs and safety devices
- Remove all the silt and debris in the drains
- Dig out any undesirable vegetation growing in the drains
- Slash any tall grass within the drains where the correct profile is established
- If necessary, repair the base of the drain channel and side slopes using template to restore correct drain profile and dimensions
- Ensure that all the cleared silt and debris is placed well clear of the drain to avoid washing back and blocking the drains when it rains
- Measure the length of drain cleared
- Clean up the area and remove temporary signs and safety devices.

**Description of bill item:**
4-02a: Clear drains of all obstacles interfering with flow of water. Unit of measurement shall be metres of drains cleared.
### DEFECT 4-02b

**Activity:** Drain cleaning (mechanised) m

**Scope of works:** Cleaning of side drain and removing silt and debris.

**Specifications:**
- Place warning signs and safety devices
- Clear all silt and debris from the side drains
- Flatten the windrow on the top outer side of the drain and clear all loose material
- Measure the drain width and length and record the measurements
- Remove traffic control signs and safety devices.

**Description of bill item:**
4-02b: Clear drains of all obstacles interfering with flow of water. Unit of measurement shall be metres of drains cleared.

### DEFECT 5-01

**Activity:** Repair erosion Damage (selected fill) m³

**Scope of works:** Involves repair of erosion damage on road shoulders, slopes and drain using selected fill material.

**Specifications:**
- Place warning signs and safety devices
- Measure the area to be repaired and record the width, length and depth of the damaged area
- Cut eroded area to firm ground and remove all unsuitable material from the excavated area
- Replace with selected fill material in layers of 50-75mm
- Add water to optimum moisture content and compact each layer of the material to density of surrounding ground
- Clear site of left over loose material and record quantity of fill material used.
- Remove traffic control signs and safety devices.

**Description of bill item:**
5-01: Repair of erosion damages on road shoulders, slopes and drain using selected fill material. Unit of measurement shall be cubic metres of repair.

### DEFECT 5-02a

**Activity:** Repair erosion Damage (rock fill) m³

**Scope of works:** Involves repair of erosion damages on road shoulders, slopes and drain using rock fill.

**Specifications:**
- Place warning signs and safety devices
- Measure the area to be repaired and record the width, length and depth of the damaged area
- Place all rocks individually with the broad side on the bottom starting with the bigger rocks and filing gages with medium and small ones interlocking and minimising void space.
- Place the smaller rocks to form a filter
- Avoid placing rocks on the carriageway or too close to the road
- Clear the area of left over rock and debris
- Remove traffic control signs and safety devices.

**Description of bill item:**
5-02a: Repair of erosion damages on road shoulders, slopes and drain using rock fill. Unit of measurement shall be cubic metres of repair.
### DEFECT 5-02b

**ACTIVITY**

Terracing and Wattling m²

**Scope of works:** Involves cutting terraces along the contour and placing wattles to prevent erosion of the soil.

**Specifications:**
- Place warning signs and safety devices
- Excavate small trench along slope contour
- Place stakes along the trench edge
- Place wattles into the trench with ends overlapping
- Secure dead stakes through the middle of wattles
- Cover the trenches using excavated soil
- Water the area and clear excess material
- Remove traffic control signs and safety devices.

**Description of bill item:**

5-02b: Repair of erosion damages on road shoulders, slopes and drain using wattles. Unit of measurement shall be area in m² repaired.

### DEFECT 6-01

**ACTIVITY**

Mortared masonry repair m³

**Scope of works:** Repair of damaged section of mortared masonry works and re-instating the structure to as close as possible to its original condition.

**Specifications:**
- Place warning signs and safety devices
- Measure the area to be repaired and record the width, length and depth of the damaged area
- Remove damaged stone work and clear rubble, and then prepare the surface
- Excavate the trench for any foundations required down to rock or firm ground to a minimum depth of 300mm
- Prepare mortar for use during the placing of rocks in quantities that can be used within an hour. Mortar mix according to ERA Specifications
- Place mortar on the bottom of the trench and lay stones in the bed of mortar 10 - 40mm thick
- Select and place stones adjacent to each other with mortar between them, ensuring regular joint width
- Clean all exposed surfaces of excess mortar
- Cure the mortar using wet sacking for a minimum of seven days from the day of repair works
- Clear site of loose materials
- Remove traffic control signs and safety devices.

**Description of bill item:**

6-01: Repair of damaged section of mortared masonry works. Unit of measurement shall be volume in m³ repaired.
### DEFECT 6-02

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Dry masonry repair m³</th>
</tr>
</thead>
</table>

**Scope of works:** Repair of damaged section of dry masonry works and reinstating the structure to as close as possible to its original condition.

**Specifications:**
- Place warning signs and safety devices
- Measure the area to be repaired and record the width, length and depth of the damaged area
- Remove damaged stone work and clear rubble, and then prepare the surface
- Excavate the trench for any foundations required down to rock or firm ground to a minimum depth of 300mm
- Lay shaped stones neatly packing them on a bedding of sand
- Wedge joints with smaller chips to secure stones in place and fill in the voids with sand to restrain movement
- Construct edges and top with mortared stone to restrain movement of packed stones.
- Clear site of left over stones and debris
- Remove traffic control signs and safety devices.

**Description of bill item:**
6-02: Repair of damaged section of mortared masonry works. Unit of measurement shall be volume in m³ repaired.

### DEFECT 7-01

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Gabion structure repair m³</th>
</tr>
</thead>
</table>

**Scope of works:** Repair damaged gabion baskets and re instate.

**Specifications:**
- Place warning signs and safety devices
- Dismantle damaged gabion and clear the site for repair
- Measure the area and volume of work required to make good the damaged extent of gabions
- Shape the gabion basket into a regular shape with all sides straight and symmetrical
- Place gabion against a firm excavated wall or next to an existing gabion basket
- Secure the gabion by tying it to the adjacent gabion(s)
- Fit bracing ties as necessary
- Fill the gabion basket manually with hard durable stones no larger than 250mm but no smaller than the size of the mesh wire forming the gabion
- Pack the stones tightly against each other to form a solid structure
- Slightly overfill the basket to allow for settlement of the stones
- Tack the gabion lid with tying wire and firmly secure the lid to the sides using tying wire.
- Remove all loose debris and signage.

**Description of bill item:**
7-01: Repair damaged gabion baskets and re instate. Unit of measurement shall be volume in m³ of gabion repaired.
**DEFECT 8-01** | **ACTIVITY**
--- | ---
Build stone wooden /scour checks No

**Scope of works:** Repair erosion damage on side drains constructed on slope greater than 4%.

**Specifications:**
- Place warning signs and safety devices
- Scour checks shall be constructed across the full width of the drain affected by erosion
- The spacing of scour checks varies according to soil type and gradient of the drain
- Shape the damaged drain to restore the original shape of the drain
- The gradient of the side drain should be checked with an Abney level or line and level to determine the requirements for scour checks (spacing guidance in the ERA LVR Design Manual)
- Check Dams should not normally be constructed on drains with gradients of less than 4%. This would encourage too much silting of the drain and could lead to road damage
- The Check Dams must not be too high otherwise water will be forced onto the surrounding ground, the shoulder or the roadway. The Check Dam construction should therefore be controlled with the aid of a template
- After the basic Check Dam has been constructed, an apron should be built immediately downstream either using stones or grass turves pinned to the drain invert with wooden pegs. The apron will help resist the forces of the water flowing over the Check Dam. Grass sods should be placed against the upstream face of the Check Dam, to prevent water seeping through the Check Dam and to encourage the silting behind the Check Dam. The long term objective is to establish complete grass cover over the silted Check Dams to stabilise them
- Water the new vegetation until established
- Clear loose material and count and record number of scour checks repaired/constructed.

**Description of bill item:**

8-01: Repair erosion damage on side drains constructed on slope greater than 4%. Unit of measurement shall be number of scour checks repaired/constructed.

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**EARTH ROADS CARRIAGEWAY MAINTENANCE ACTIVITIES**

**DEFECT 9-01** | **ACTIVITY**
--- | ---
Re shape and compact earth road camber m²

**Scope of works:** Repair potholes and damaged earth road surface and reshape camber using labour.

**Specifications:**
- Place warning signs and safety devices
- Drain off any standing water
- Excavate damaged section to firm ground
- Remove all unsuitable material from damaged pothole or gully
- Reshape the camber to the correct profile using additional suitable material if necessary, moisten and backfill the damaged section in layers between 50 – 75mm
- Compact to density of surrounding ground maintaining free draining camber
- Remove traffic control signs and safety devices
- Place warning signs and safety devices.

**Description of bill item:**

9-01: Reshape earth road camber by labour and repair potholes and ruts. Unit of measurement shall be m² of earth road re shaped.
### GRAVEL ROADS CARRIAGEWAY ACTIVITIES

<table>
<thead>
<tr>
<th>DEFECT 10-01</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spot repair selected material m³</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of potholes, ruts and soft spots on gravel road surface using selected gravel material.

**Specifications:**
- Place warning signs and safety devices
- Excavate and shape the hole to a depth of 75 - 100mm minimum. Measure the excavated hole and record the measurements
- Remove any debris, standing water and loose material or mud.
- Add water to selected gravel material (to ERA Surfacing gravel specifications) to achieve optimum moisture content
- Backfill the gravel material in layers of 50 to 75mm and compact using a hand rammer.
- Remove any surplus material and tidy up the place
- Remove traffic control signs and safety devices.

**Description of bill item:**
10-01: Repair of potholes on road surface using selected material. Unit of measurement shall be in m³ of placed material.

<table>
<thead>
<tr>
<th>DEFECT 10-02</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spot repair crushed aggregate m³</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair potholes, ruts and soft spots on gravel surfaces using crushed stone aggregate.

**Specifications:**
- Place warning signs and safety devices
- Excavate and shape the hole to a depth of 75 - 100mm minimum. Measure the excavated hole and record the measurements
- Remove any debris, standing water and loose material or mud
- Level the base of the hole and add water to improve bond with crushed aggregate
- Moisten the crushed aggregate (to ERA crushed stone aggregate paving specifications) and fill the hole with the crushed stone aggregate in layers of 50 - 75mm
- Compact the crushed fill aggregate to maximum density
- Remove any surplus material and tidy up the area
- Remove traffic control signs and safety devices.

**Description of bill item:**
10-02: Repair potholes, ruts and soft spots on gravel surfaces using crushed stone. Unit of measurement shall be in m³ of placed material.
### DEFECT 11-01

<table>
<thead>
<tr>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade gravel road carriageway (light) m</td>
</tr>
</tbody>
</table>

**Scope of works:** Grading of road using mechanical means to reduce roughness, improve riding quality and maintain camber

**Specifications:**
- Place warning signs and safety devices
- Grading should begin from one side of the road and progress across to the other side of the road leaving the windrow on one side. Cutting passes should be a maximum of 5cm deep. The windrow is then re-spread to the correct camber
- On average four passes across the road are sufficient to provide a smooth riding surface on a 4 to 5m carriageway
- On completion clear all loose stones and windrows from the carriageway
- Measure the lengths of road maintained and record the measurements
- Remove traffic signs and safety devices.

**Description of bill item:**
11-01 Light grading of road surface to reduce roughness, improve riding quality and maintain camber. Unit of measurement shall be in carriageway-m of road graded.

### DEFECT 12-01

<table>
<thead>
<tr>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blade gravel road carriageway (heavy) m</td>
</tr>
</tbody>
</table>

**Scope of works:** Mechanical grading gravel, scarify and move the material into a windrow and then mix and spread into required profile.

**Specifications:**
- Place warning signs and safety devices
- Rip and scarify the existing road surface and push into a windrow towards the centre of the road
- Additional material can be added if necessary
- Water and mix the material thoroughly
- Spread the material and compact forming the required profile
- Remove loose stones and windrows from the carriageway
- Remove traffic signs and safety devices.

**Description of bill item:**
12-01: Heavy grading of road surface to correct deep ruts, corrugations, potholes and camber. Unit of measurement shall be in carriageway-m of road graded.
# GRAVEL OR PAVED ROADS

## DEFECT 13-01

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Gravel resurfacing (selected material) m³</th>
</tr>
</thead>
</table>

**Scope of works:** Re-gravelling of road section involving bringing in additional natural gravel to supplement existing layer, water, mix and compact.

**Specifications:**
- Place warning signs and safety devices
- Provide a detour for use by traffic during re-gravelling exercise, or arrange suitable traffic control
- Repair any localised damage on the subgrade or pavement before re-gravelling (10-01 or 10-02)
- Scarify existing gravel layer to ensure bond with new material
- Bring in additional approved gravel and dump along the road at specified intervals
- Spread, water and mix the gravel then form the surface into required camber or cross fall as specified by the Engineer or representative
- Clear all oversize stones and loose windrows
- Remove traffic control signs and safety devices.

**Description of bill item:**

13-01: Re-gravelling of road section and compacting the new road pavement. Unit of measurement shall be in m³ of compacted gravel laid.

## DEFECT 14-01a

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>Spot pothole repair (Macadam) m²</th>
</tr>
</thead>
</table>

**Scope of works:** Repair damaged area/spot using Stone Macadam.

**Specifications:**
- Place warning signs and safety devices
- Clean the area thoroughly using a broom
- Trim the hole into a regular rectangular shape with level base
- Fill the hole with stone macadam material allowing extra fill for settlement after compaction
- Moisten and compact thoroughly with a hand rammer or mechanical roller.
- Tidy up the area of loose material
- Remove traffic control signs and safety devices.

**Description of bill item:**

14-01a: Repair damaged area/spot using Stone Macadam. Unit of measurement shall be in m² of pothole repaired.
### DEFECT 14-01b

**ACTIVITY**

Spot pothole repair (Stone setts) m²

**Scope of works:** Repair damaged section of road stone setts.

**Specifications:**
- Place warning signs and safety devices
- Remove damaged stone setts
- Remove the bedding and expose the damaged area
- Level the base and moisten then compact
- Re-lay the bedding to original thickness
- Re-lay the stone setts and replace damaged ones
- Spread fine sand over there laid stone setts to fill joints and ensure interlocking
- Tamp the stone setts with a hammer to pack properly
- Clean up loose material and left over sand
- Remove traffic control signs and safety devices.

**Description of bill item:**

14-01B: Repair damaged section of road stone setts. Unit of measurement shall be in m² of area repaired.

### DEFECT 14-01c

**ACTIVITY**

Spot pothole repair (Mortared stone) m²

**Scope of works:** Repair damaged section of mortared stone.

**Specifications:**
- Place warning signs and safety devices
- Remove damaged stone and clear the site for repair
- Measure the area of work required to make good the damaged area
- Sprinkle some water on the cleared area and compact
- Prepare mortar and place on the base area to be repaired
- Place clean stones on the mortar bedding adjacent to each other with mortar in between them to bond
- Clean the stones of excess mortar remove all loose material and dirt
- Remove traffic control signs and safety devices.

**Description of bill item:**

14-01c Repair damaged section of mortared stone. Unit of measurement shall be area in m² repaired.
<table>
<thead>
<tr>
<th>DEFECT 14-01d</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot/ pothole repair (Dressed stone) m²</td>
<td></td>
</tr>
</tbody>
</table>

**Scope of works:** Repair damaged section of dressed stone.

**Specifications:**
- Place warning signs and safety devices
- Remove damaged dressed stone pieces
- Remove the bedding and expose the damaged area
- Level the base and moisten then compact.
- Re-lay the bedding to original thickness
- Re-lay the dressed stone and replace damaged ones
- Spread fine sand over there laid dressed stone to fill joints and ensure interlocking
- Tamp the dressed stone with a hammer to pack properly
- Clean up loose material and left over sand
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01d: Repair damaged section of road dressed stone. Unit of measurement shall be in m² of area repaired.

<table>
<thead>
<tr>
<th>DEFECT 14-01e</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot /pothole repair (Emulsion chip seal) m²</td>
<td></td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of dry brittle or fretting road surface.

**Specifications:**
- Place warning signs and safety devices
- Clean, dry and brush area to remove dirt, dust and deleterious material from the area to be maintained
- Apply specified bitumen emulsion at the required rate of spread on the area to be repaired
- Immediately apply single size clean dust free aggregate chips on the area sprayed with bitumen
- Lightly roll the chippings after the emulsion has ‘broken’
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01e: Repair of dry brittle or fretting road surface with emulsion chip seal Unit of measurement shall be in m².

<table>
<thead>
<tr>
<th>DEFECT 14-01f</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot /pothole repair (Emulsion sand seal) m²</td>
<td></td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of dry brittle or fretting road surface.

**Specifications:**
- Place warning signs and safety devices
- Clean, dry and brush area to remove dirt, dust and deleterious material from the area to be maintained
- Apply specified bitumen emulsion at the required rate of spread on the area to be repaired
- Immediately apply single size clean dust free sand on the area sprayed with bitumen
- Lightly roll the sand layer after the emulsion has ‘broken’
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01f: Repair of dry brittle or fretting road surface with emulsion sand seal. Unit of measurement shall be in m².
<table>
<thead>
<tr>
<th>DEFECT 14-01g</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot/ pothole repair (Emulsion gravel seal) m²</td>
<td></td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of dry brittle or fretting road surface.

**Specifications:**
- Place warning signs and safety devices
- Clean, dry and brush area to remove dirt, dust and deleterious material from the area to be maintained
- Apply specified bitumen emulsion at the required rate of spread heated bitumen on the area to be repaired
- Immediately apply selected gravel material on the area sprayed with bitumen
- Lightly roll the gravel layer after the emulsion has ‘broken’
- Remove traffic control signs and safety devices.

**Description of bill item:**
114-01g: Repair of dry brittle or fretting road surface with emulsion gravel seal. Unit of measurement shall be in m².

<table>
<thead>
<tr>
<th>DEFECT 14-01h</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot/ pothole repair (Un-mortared brick) m²</td>
<td></td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of damaged section of Un-mortared brick.

**Specifications:**
- Place warning signs and safety devices
- Remove damaged bricks
- Remove the bedding and expose the damaged area
- Level the base and moisten then compact
- Re-lay the bedding to original thickness
- Re-lay the bricks and replace damaged/missing ones
- Spread fine sand over there laid bricks to fill joints and ensure interlocking.
- Carefully tamp the bricks with a hammer or plate compactor to pack properly
- Clean up loose material and left over sand
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01h: Repair of damaged section of un mortared brick. Unit of measurement shall be in m².

<table>
<thead>
<tr>
<th>DEFECT 14-01i</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot/ pothole repair (Mortared brick) m²</td>
<td></td>
</tr>
</tbody>
</table>

**Scope of works:** Repair damaged section of mortared brick.

**Specifications:**
- Place warning signs and safety devices
- Remove damaged brick and clear the site for repair
- Measure the area and volume of work required to make good the damaged area
- Sprinkle some water on the cleared area and compact
- Prepare mortar and place on the base area to be repaired
- Place clean bricks on the mortar bedding adjacent to each other with mortar in between them to bond.
- Clean the stones of excess mortar remove all loose material and dirt
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01i: Repair damaged section of mortared brick. Unit of measurement shall be in m².
<table>
<thead>
<tr>
<th>DEFECT 14-01j</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spot/ pothole repair (Non reinforced concrete) m²</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of damaged non-reinforced concrete pavement or base.

**Specifications:**
- Place warning signs and safety devices
- Break damaged area to expose extent of damage
- Clean the area of dirt, dust and chips
- Place concrete to the required specification
- Level the surface neatly to match surrounding area, tamp it to remove voids and groove the surface for skid resistance
- Cure the concrete and protect it from traffic for 7 days
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01j: Repair damaged section of Un-reinforced concrete. Unit of measurement shall be in m².

<table>
<thead>
<tr>
<th>DEFECT 14-01k</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spot /pothole repair (Reinforced concrete) m²</td>
</tr>
</tbody>
</table>

**Scope of works:** Repair of damaged reinforced concrete pavement or base.

**Specifications:**
- Place warning signs and safety devices
- Break damaged area to expose extent of damage
- Expose, remove and replace any damaged reinforcement
- Clean reinforcement to remove any rust/scale
- Clean the area of dirt, dust and chips
- Place concrete to the required specification
- Level the surface neatly to match surrounding area
- Tamp it to remove voids and groove the surface for skid resistance
- Cure the concrete and protect it from traffic for 7 days
- Remove traffic control signs and safety devices.

**Description of bill item:**
14-01k: Repair damaged section of reinforced concrete. Unit of measurement shall be in m².
### DEFECT 14-01I

**Activity**: Spot/ hole reinstatement (Cold mix) m³

**Scope of works**: Repair of surface damage potholes and worn out patches.

**Specifications**:
- Place warning signs and safety devices
- Excavate failed material to sound firm base
- Remove all loose material from hole
- Level and moisten the hole base and compact
- Backfill using emulsion cold mix material
- Allow extra material for settlement after compaction
- Compact level with surrounding area
- Tidy up the area of loose material
- Remove traffic control signs and safety devices.

**Description of bill item**:
14-01I: Repair of weak and deformed road foundation. Unit of measurement shall be in m³ of placed and compacted material.

### DEFECT 14-01m

**Activity**: Pothole (Base failure) m³

**Scope of works**: Repair of weak and deformed road foundation.

**Specifications**:
- Place warning signs and safety devices
- Excavate failed material to sound firm base
- Remove all loose material from hole
- Level and moisten the hole base and compact
- Backfill using crushed stone or selected road base material as directed by the Engineer
- Allow extra material for settlement after compaction
- Compact level with surrounding area
- Tidy up the area of loose material
- Remove traffic control signs and safety devices.

**Description of bill item**:
14-01M: Repair of weak and deformed road foundation. Unit of measurement shall be in m³.
### DEFECT 15-01

**ACTIVITY**
Clean dirty road sign

**Scope of works:** Clean Dirty Road Sign

**Specifications:**
- Place warning signs and safety devices
- Clean sign face using cloth, water and detergent solution
- Remove all traces of detergent with a cloth and soft brush and rinse with water
- Clean the back of the sign and the supporting structure using water and cloth
- Remove dirt from corners of fittings
- Count and record the number and type of road signs cleaned
- Tidy up the site and remove all traffic signs and safety devices.

**Description of bill item:**
15-01: Clean dirty signs and remove dust. Unit of measurement shall be number of signs cleaned.

### DEFECT 16-01

**ACTIVITY**
Repainting road sign

**Scope of works:** Repaint road sign to keep it in good and easily readable condition at all times.

**Specifications:**
- Place warning signs and safety devices
- Remove the rusted or faded road sign from supporting structure and transport to a designated workshop
- Prepare surfaces to be painted by cleaning them using steel brushes, scraping or sand paper to remove all forms of dirt and corrosion
- Scrub with clean water using a brush and allow to dry
- Paint or spray paint the primer and finish coat on sign face and reverse side in accordance with paint manufacturer’s specifications
- Transport the sign back to the road and install the sign on the support structure
- Scrub, clean and repaint the sign support on site
- Count and record the number of signs and sign supports repainted
- Tidy up the site and remove all traffic control signs and safety devices.

**Description of bill item:**
1-01: Repainting of faint road signs. Unit of measurement shall be number of signs repainted.

### DEFECT 16-02

**ACTIVITY**
Replacing road sign

**Scope of works:** Replace defective road sign

**Specifications:**
- Place warning signs and safety devices
- Remove the defective sign and post as directed
- Supply and erect new sign and post as directed and to ERA Specifications
- Tidy up the site and remove all traffic control signs and safety devices.

**Description of bill item:**
16-02: Replacing defective sign. Unit of measurement shall be number of signs replaced.