NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

LAND RECLAMATION, LANDSLIDE TREATMENT

(No. and Ac.)

CODE 453

DEFINITION

Managing in-place natural materials, mine spoil (excavated over-burden), mine waste or overburden to reduce down-slope movement.

PURPOSE

- Repair unstable slopes caused by slope failure, and reduce the likelihood of enlargement or renewed movement of slope surfaces;
- Protect life and property;
- Prevent excessive erosion and sedimentation;
- Improve water quality and landscape resource quality; and
- Create a condition conducive to establishing surface protection and beneficial land use.

CONDITIONS WHERE PRACTICE APPLIES

To areas where in-place material, mine spoil, waste, or overburden, or rock cut road banks are unstable, moving, or judged to have potential of moving down slope in a manner that will cause damage to life, property, or the environment. It does not apply to constructed embankment surfaces such as road fills, dams, dikes, levees and terraces.

CRITERIA

Investigations. Investigations shall include and extend beyond the area of the landslide and shall be made to determine:

1. Surface profiles, cross sections, and topographic features
2. Geologic profiles and cross sections showing attitude and conditions of strata and details of the slip zone
3. Soil classification and properties, including gradation, density, strength, and chemical characteristics
4. Ground-water conditions
5. Depth, extent, and volume of material involved
6. Estimated pre-slide profile and subsurface conditions
7. Conditions where slopes are stable in similar materials
8. Extrinsic factors (e.g. land use activities and/or precipitation events) that triggered or remobilized the failure.

Extreme caution must be exercised and careful planning is required before permitting any personnel, drilling equipment, or construction machinery, in the slide area. A slide is often active during wet periods and may be comparatively stable during dry periods.

Slope stability. Measures developed to prevent or stabilize slides shall be based on engineering analysis and judgment made by an engineer trained and experienced in soil mechanics or soil bioengineering.

Slope stability analysis shall account for all critical soil and loading conditions. The strength parameters of natural soil and rock or of waste materials shall be based on the appropriate conditions for each slide. Long-term strength parameters (c=0 and internal friction based on residual shear) shall be used. The methods of slope stability analysis are to be appropriate for the loading conditions and

for the location and shape of sliding or potential failure surfaces.

Appropriate safety factors shall be provided based on the degree of uncertainty in the soil strength values used, the soil and water conditions assumed, and the detail of the analysis used.

When there is a potential for loss of life or damage to farmsteads, residential areas, frequently traveled roads, occupied facilities, or important public utilities, the measures shall include removal of the material subject to sliding or any other control to ensure safety.

The requirements contained in the NRCS National Engineering Manual Part 531.26 (a) shall apply for the geologic investigations and seismic assessments. Criteria for minimum seismic coefficients and recurrence interval shall be as required in the state building code.

Water control. Sources of water that will enter the landslide area shall be controlled to the extent possible in accordance with the following:

- **Surface runoff water.** Runoff water that would enter the landslide area is to be intercepted and conveyed to a stable outlet.
- **Water from direct precipitation.** Infiltration shall be limited to the extent possible by providing positive surface drainage and sealing surface cracks within the area. Grading and shaping may be required to provide positive surface drainage. Terraces structures and waterways are to be installed as needed to provide safe water disposal without erosion and with positive grade to reduce seepage. The surface of the treated area shall be protected from erosion as appropriate.
- **Ground water.** Design measures, including vegetative treatment where appropriate, shall be taken to intercept ground water that contributes to instability of the area. Drainage systems shall be designed in accordance with Part 633, Chapter 26 of the National Engineering Handbook, and the system shall be designed to remain operational in the event of limited movement of the area after construction.

Earth material control. The design shall take into consideration the following factors impacting loading, strength or counter-buttressing as appropriate:

- earth material
- internal water
- rock material

- **Loading control.** Where appropriate, consider alternatives for loading control, including: removing excess material from the upper portions of the slide mass; removing the entire slide mass; dewatering at least the upper portion of the slide, and removing excess weight associated with development. Sites for safe disposal of excavated slide material should be identified as part of planning and design.
- **Slope reduction.** Critical slopes within the slide area shall be reduced by grading when practical.
- **Increasing internal strength.** The design shall analyze the impact of removing and recompacting material at designed levels of moisture and compactive effort. It shall also analyze the impact of biotechnical slope stabilization practices.
- **External restraints.** External restraints shall be used where slope movements must be limited due to high-valued improvements, and where manipulation of the earthen material may not achieve the desired results. External restraints shall be designed to withstand overturning, sliding at or below the base, and bearing failure of the foundation. All measures shall include provisions for proper drainage.

Vegetative treatment. Vegetation shall be planted using selected soil bioengineering or biotechnical slope stabilization techniques appropriate to the site. Deep rooted grasses and shrubs with proven performance in soil bioengineering applications shall be used. The transpiration potential and rooting depth of the vegetation applied shall be considered. Site conditions including soil pH, particle size, and nutrient content shall be analyzed, and this information used to select the appropriate vegetative treatment and plant materials for the site.

Component practices. All individual practices installed as a component of landslide treatment are to be designed and installed in accordance with applicable NRCS conservation practice standards and specifications. If NRCS standards are not available, the practice is to be designed and installed using current engineering technology.

Environmental. All disturbed areas are to be provided with adequate water disposal systems and established to vegetative cover, or otherwise protected, to control erosion and sediment as soon as practicable. Temporary protective measures will be necessary if a long delay is anticipated in establishing permanent cover. Human, animal and vehicular traffic is to be controlled to protect the area.

CONSIDERATIONS

Consider offsite water quality effects such as acid mine drainage.

In drainage systems, pipes should be used with caution because of the potential of breaking and/or misalignment with further movement. Flat or nearly flat gradients should be avoided for the same reasons.

Consider visual resources with other design features during planning, design, and installation. All disturbed areas should be reshaped and regraded to blend in with the surrounding land features.

PLANS AND SPECIFICATIONS

Plans and specifications for slide treatment shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

The maintenance plan is to include periodic inspections for additional movement, failure of water disposal systems, vegetation, and other problems. The water disposal system, subsurface drainage system, access roads, and vegetative cover are to be maintained to accomplish their intended purposes. Necessary maintenance and repair activities are to be initiated promptly.

REFERENCES

Landslides: Investigation and Mitigation. Special Report 247. 1996. Transportation Research Board, National Research Council, National Academy Press, Washington, D.C., 673 p.

National Engineering Handbook. Chapters 16, 18, 26. USDA-NRCS.

Rural Abandoned Mine Program (RAMP) Handbook. USDA-NRCS.

APPROVAL AND CERTIFICATION

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PRACTICE STANDARD APPROVED:

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Date

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