Canal Sloughing

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Canal Sloughing

- What is it?
- What causes it?
- Repairing it
What is it?

Canal Slope Failure

• Canal slope failures classified into three types:
  – Sloughs
  – Slumps
  – Rotational Failures
**Sloughs**

- The term “slough” refers to the loss of a thin skin of material from the surface of a slope. It is used to describe those cases where only the armour is displaced and virtually none of the underlying bank material is affected.

**What Causes it?**

- Typically, two conditions lead to this type of failure: a weak interface between the armour and the material below it, and the removal of toe support at the base of the canal (that helps to hold the armour in place).

- A slough often appears following:
  - Freeze thaw cycles, especially in the spring
  - Rapid canal draw down during the operation season
  - Soon after canal de-watering in the fall
Slough Failure
150mm to 200mm thickness of gravel armour has moved down the slope and piled up at the toe.
Slumps

- The term “slump” refers to a relatively shallow failure, and is where some amount of the bank material is included in the failure mass (i.e. the failure surface extends back into the bank). A slump can include a small rotational component, but typically it is contained within the canal slope itself.

What Causes it?

- The cause of this type of failure is weak or degrading material in the canal bank, above the canal invert.
- A slump often appears following:
  - Freeze thaw cycles, especially in the spring
  - Rapid canal draw down during the operational season
  - Lower than normal canal operation levels after an extended period of heavy rains
  - Soon after canal de-watering in the fall
Slump Failure
Canal armour plus 100mm to 300mm of base material has moved down the slope and piled up at the toe
Rotational Failures

- The term “rotational failures” is used to refer to a deeper-seated failure, with a strong rotational component, where the failure surface extends below the canal invert elevation, into the foundation material.

What Causes it?

- This type of failure is caused by weak materials in the foundation (and possibly also in the bank) accompanied at times with high upward hydraulic gradients. It will produce a prominent head scarp and toe bulge, resulting from the material rotating and pushing the canal base material upwards, and less downslope movement of armour and accumulation at the bank toe.

- Rotational failures often appear following:
  - Freeze thaw cycles, especially in the spring
  - Rapid canal draw down during the operational season
  - Lower than normal canal operation levels after an extended period of heavy rains
  - Soon after canal de-watering in the fall
  - A change in canal geometry
Rotational Failure
Soft foundation has given way and material has pushed up unto the middle of the canal.
Repairing Sloughs & Slumps

- Remove gravel armour accumulated at the toe
- Excavate the bank to a slope of 1H:1V, with the top of the excavation starting at least 0.5m above the failure head scarp, the bank is excavated down to the canal invert (provided soft material is not encountered at the base of the excavation)
- Backfill slope using pitrun gravel
Repairing Rotational Failures (and Possible Slumps)

- Similar to the slough/slump repair, but a key trench is constructed to a depth usually at least 1m below canal invert but not less than 0.5m.
- The key trench must extend down to competent material and may have to extend some distance beyond the toe of the slope, into the canal.
- Backfill key trench and slope with pitrun gravel.
Recommendations

• Use salvaged armour material to fill canal bottom voids along the toe or place in bottom of key trenches
• Fill excess canal bottom voids with non erodeable material
• Do not use salvaged armour material to resurface the repair area, use new gravel armour, salvaged material is usually too contaminated
• Keep operations tight, backfill key trenches to 0.5m above canal invert on same day as excavation.
What Doesn’t Work?

• Simply pulling the failed material and gravel armour back up into the failed slope and reshaping.
Photos of Failures and Repair Operations
Questions?