

GPI

Engineering | Design | Planning | Construction Management

Maintenance & Preservation Techniques for Metal Culverts

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Learning Outcomes

- ◀ Discuss common deficiencies identified in metal culverts
- ◀ Describe preventive maintenance of metal culverts
- ◀ Review repair of metal culverts

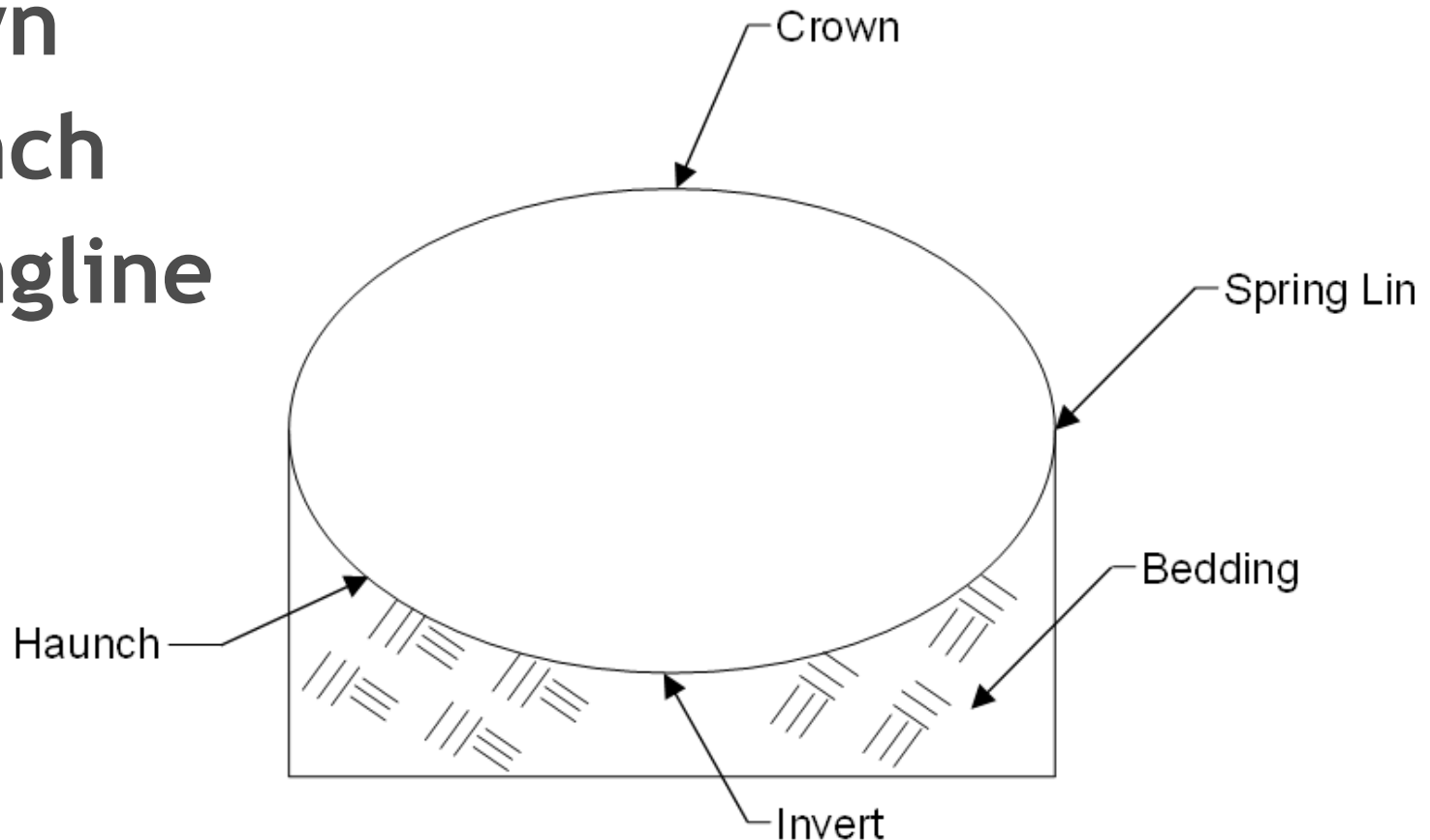
Metal Culverts

- ◀ Corrugated steel or aluminum
- ◀ Round culverts up to 15' in diameter
- ◀ Plate pipe arches up to 50' spans
- ◀ Bottomless arches up to 55' spans
- ◀ Flexible
- ◀ They rely on soil interaction for strength
- ◀ They may deform if soil is unstable
- ◀ Joints are 20' apart on preformed pipes



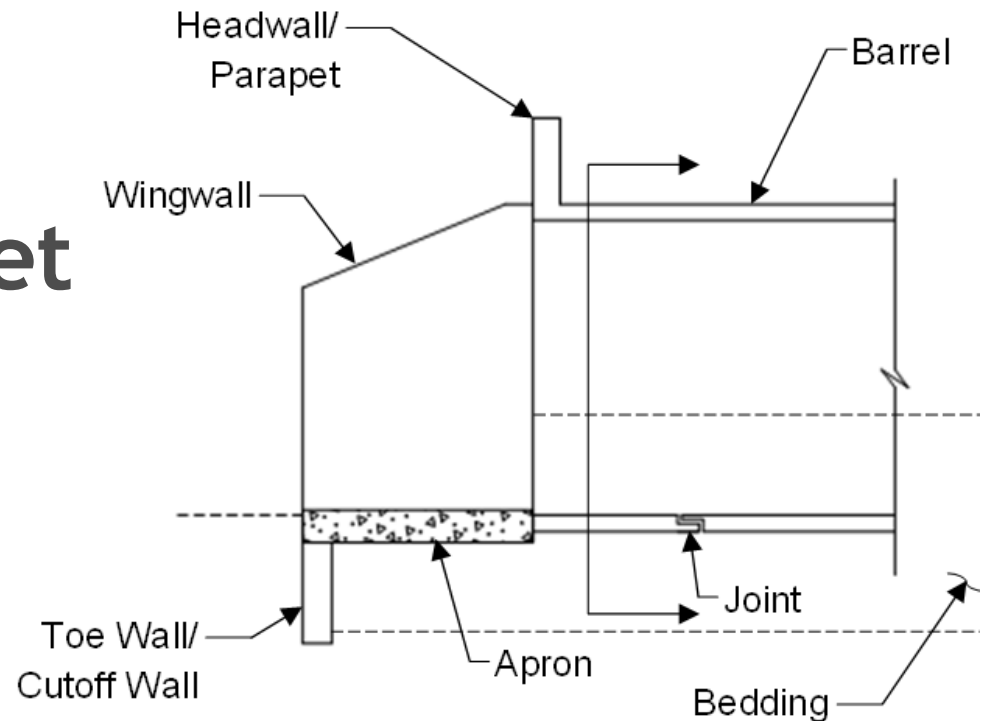
Parts of a Culvert

- ◀ Invert
- ◀ Crown
- ◀ Haunch
- ◀ Springline



Parts of a Culvert

- ◀ Apron
- ◀ Toe Wall/Cutoff Wall
- ◀ Barrel
- ◀ End Section
- ◀ Headwall/Parapet
- ◀ Joint
- ◀ Wingwall



Elevation

Importance of Culvert Installation & Maintenance

- ▶ Proper installation will reduce the maintenance necessary during the life of the culvert
- ▶ Proper maintenance will delay or prevent complete open cut replacement



Common Defects of Culverts

- ◀ Debris & siltation
- ◀ Leaking joints
- ◀ Settlement/Sinkholes
- ◀ Scour & undermining
- ◀ Piping
- ◀ Damaged coatings
- ◀ Invert damage/deterioration
- ◀ Dents & localized damage
- ◀ Deformation of pipe

Debris & Siltation

- ◀ Reduce capacity of the culvert
- ◀ Alter flow through the culvert
- ◀ May lead to scour at inlet
- ◀ May cause scour outlet
- ◀ May cause undermining
- ◀ May cause culvert to overtop



Soil in Culvert

- ◀ Reduces waterway capacity
- ◀ May be required by environmental considerations
- ◀ May result from hydraulics of stream
- ◀ May indicate failed joints



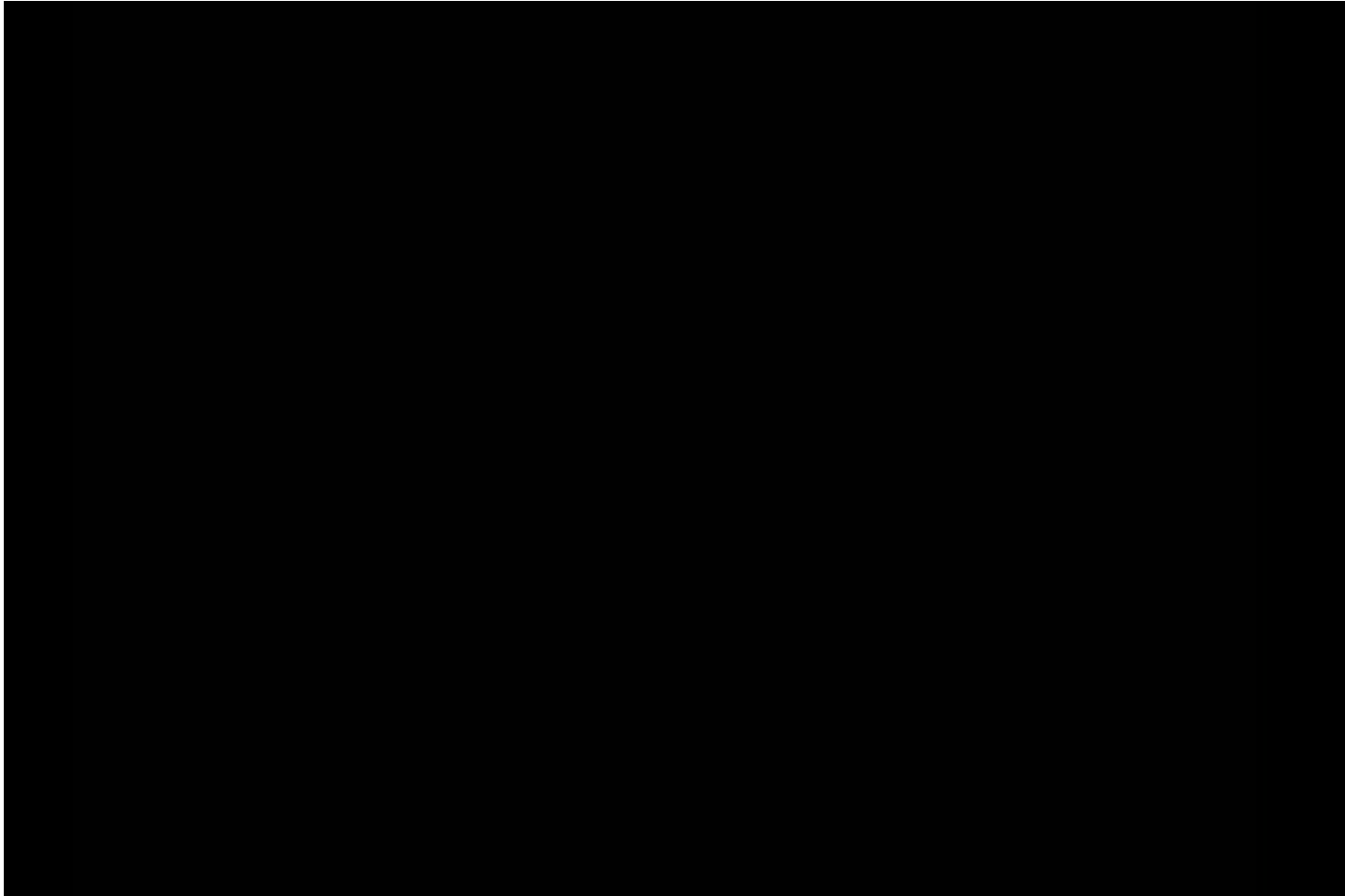
Debris in Culvert



Debris Can Cause Problems



Culvert Failure Video



Causes of Leaking Joints

- ◀ Separated or misaligned
- ◀ Damaged during installation
- ◀ Open joints
- ◀ Poor bedding / subgrade



Impact of Joint Defects

- ◀ Water infiltration or exfiltration
- ◀ Soil infiltration
- ◀ Seepage at joints
- ◀ Sink holes in the embankment/ pavement surface over the joints
- ◀ Destabilization of pipe bedding



Joint Defects

- ◀ Joint failure with loss of soil



Pavement Distress Caused by Leaking Joints



Scour & Undermining



Piping



Dents & Localized Damage

- ◀ May indicate poor installation practices
- ◀ Could have capacity impacts
- ◀ Could make joint failures more severe
- ◀ May limit relining options



Deformation of Pipe



Damaged Coatings

- ◀ Not typically a problem by itself
- ◀ Creates the opportunity for other distresses



Corrosion

- ◀ Corrosion will often start with pitting
- ◀ Acidic/saline water
- ◀ Soils with low electrical resistivity



Invert Damage & Deterioration

- ◀ Corrosion may be caused by water or soil chemistry
- ◀ Damage may be caused by abrasion
- ◀ Damage may destabilize culvert



Settlement/Sinkhole

- ◀ The sink hole is a symptom of another issue
- ◀ Caused by water carrying soils away



Settlement/Sinkhole (con.)

- Failed invert with undermined culvert



Settlement/Sinkhole (con.)

◀ Collapse



Preventive Maintenance

- ◀ Debris removal
- ◀ Sediment removal
- ◀ Vegetation removal
- ◀ Armoring for Scour protection



Removal of Debris & Silt

- Method is dependent on:
 - Type of debris
 - Size of culvert
 - Environmental restrictions



Removal of Large Debris

- ◀ **Removal of channel debris**
 - Woody debris, beaver dams, etc.
 - Inlets and outlets
- ◀ **Excavator or large equipment**
- ◀ **Cables, mandrels, or manned entry**

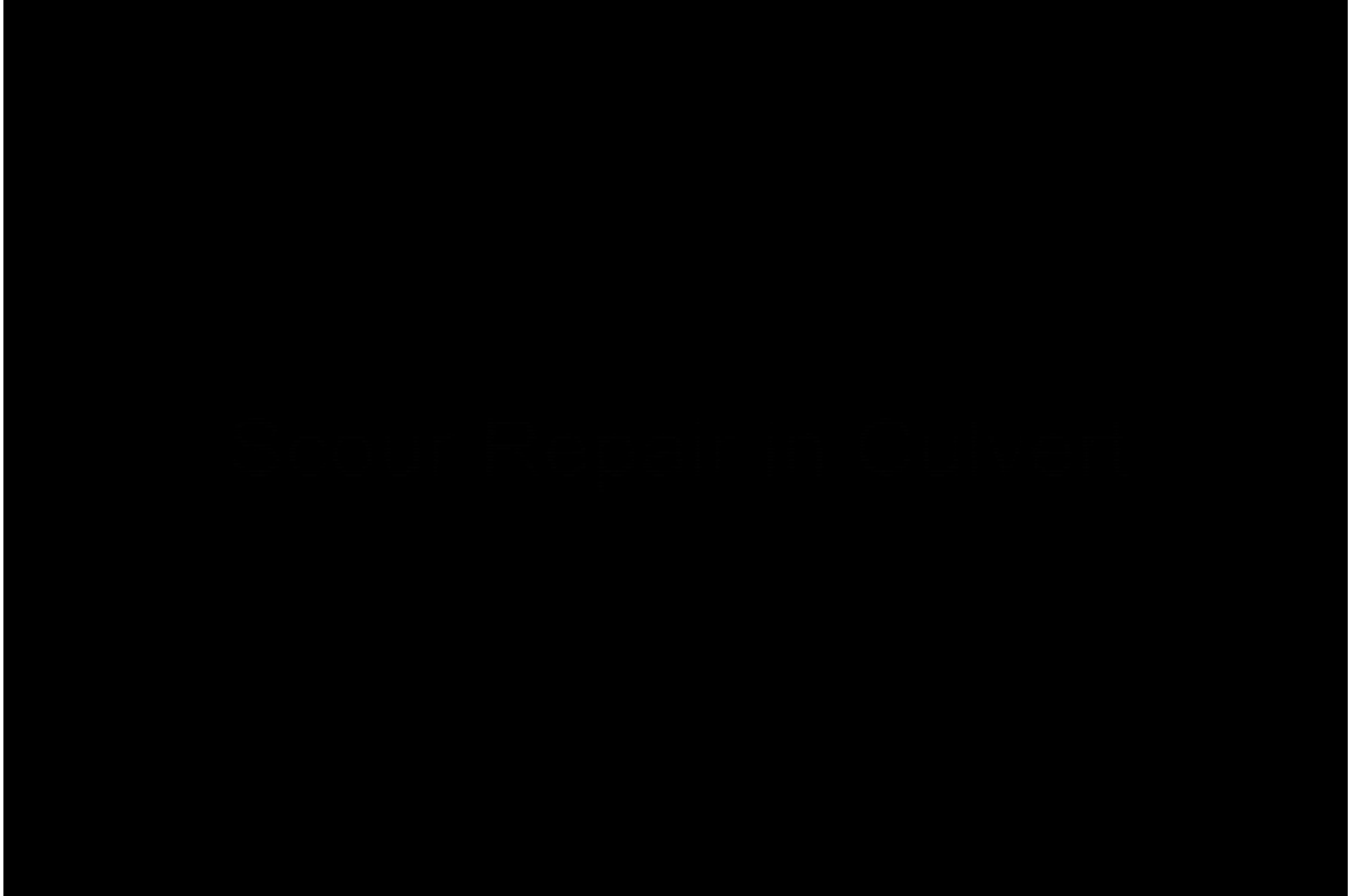
Silt Removal Methods

- ◀ Vacuum truck
- ◀ Water jet / Sewer jet
- ◀ Fire hose flushing
- ◀ Bucket line
- ◀ Small skid steer loader

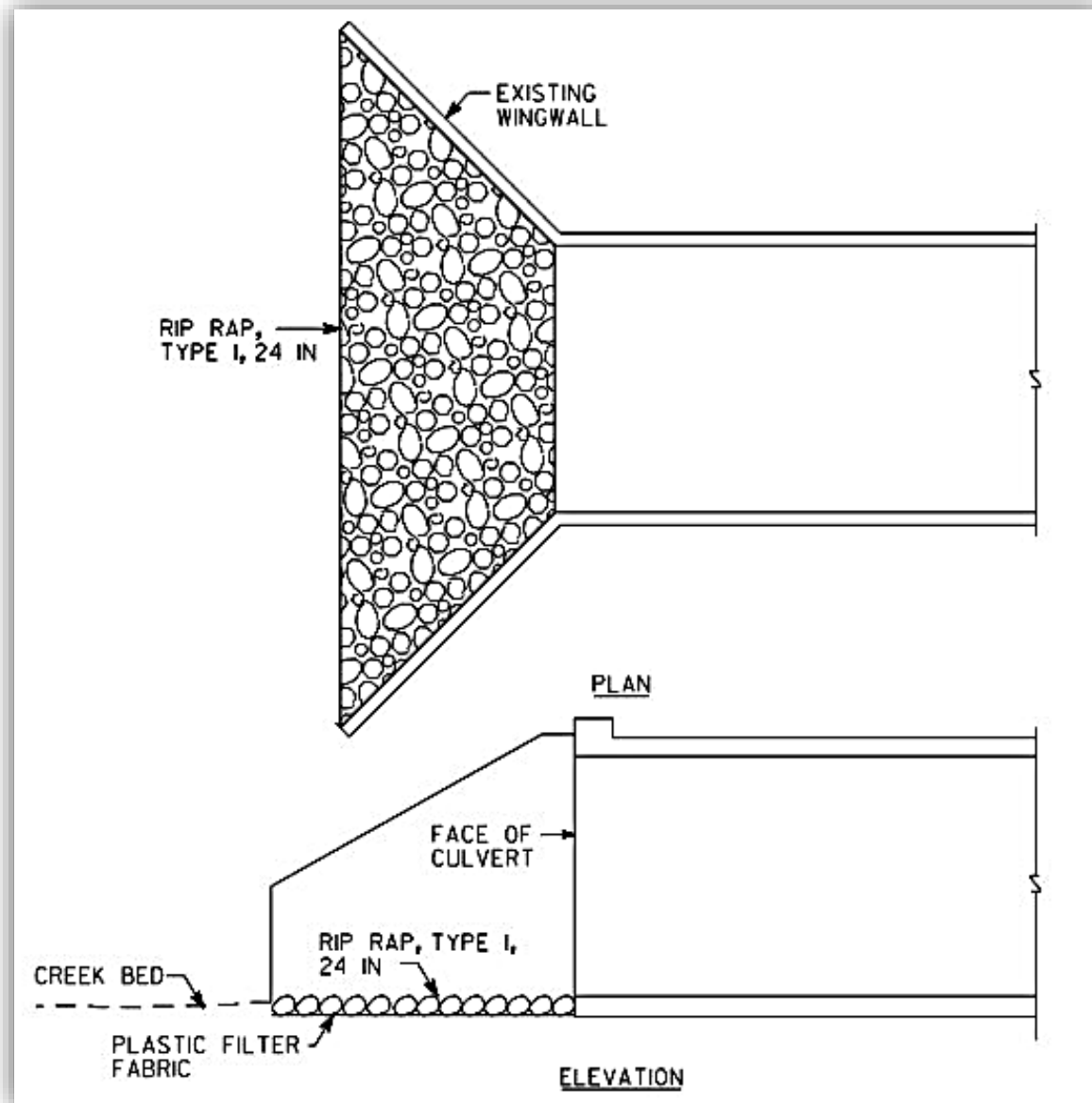
Scour Repair

- ◀ Scour repair will depend on the severity of the scour
- ◀ A hydraulics engineer should be consulted for appropriate materials
- ◀ May require various materials in addition to stone, such as grout, concrete, sand bedding and geotextile fabric
- ◀ If working in the stream, environmental permits may be required

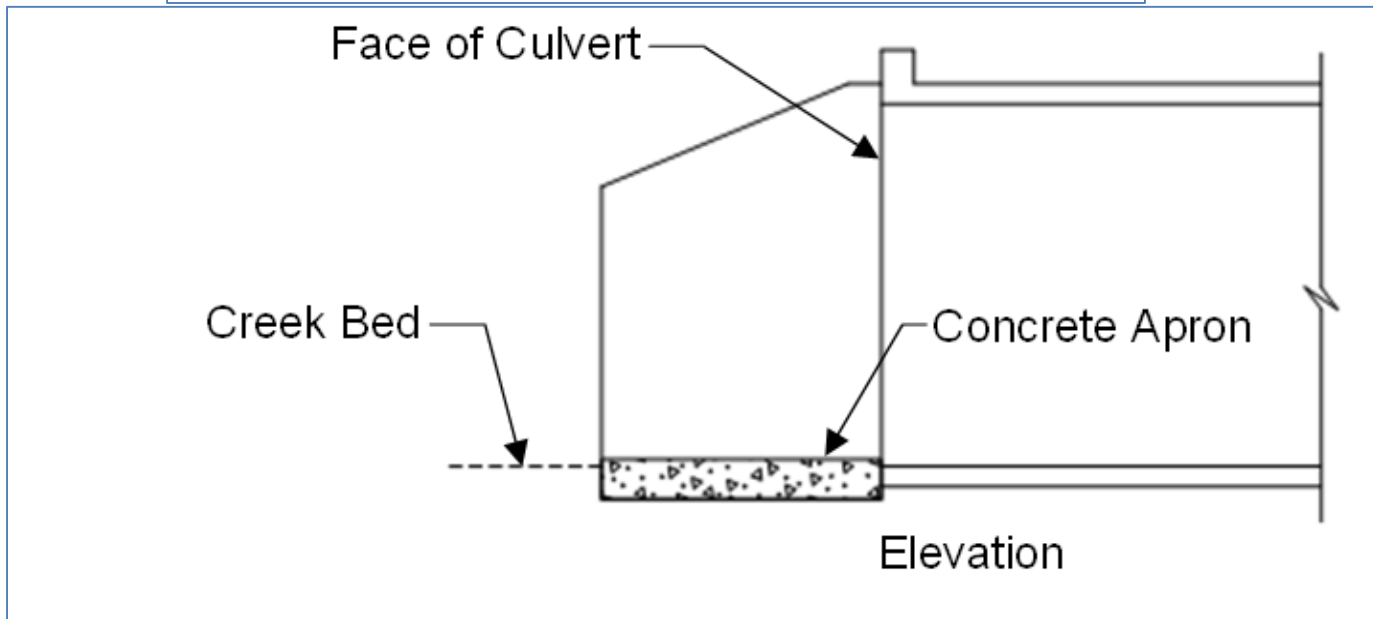
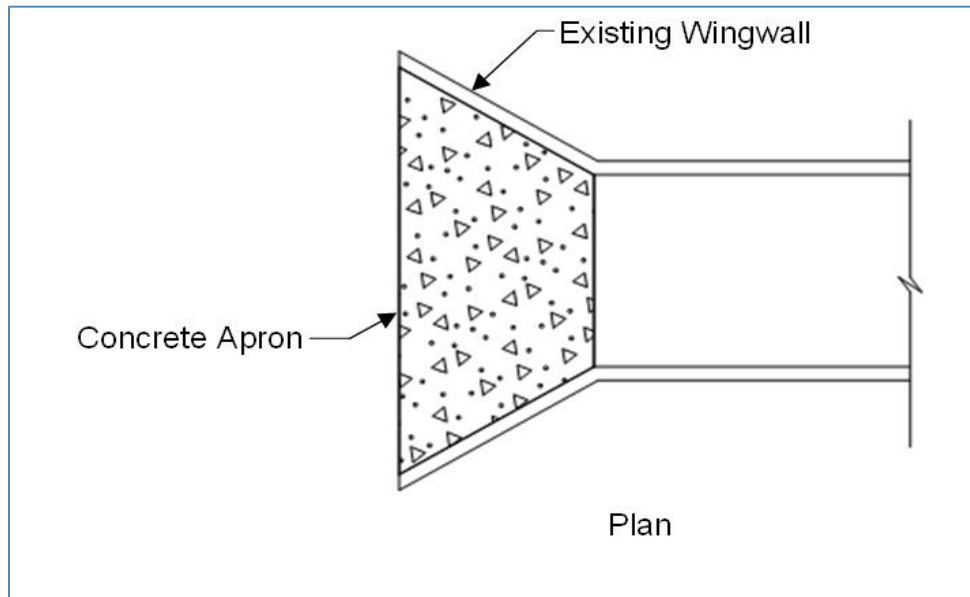
Scour Repair in Culvert Video



Scour Repair > Riprap Apron



Scour Repair > Concrete Apron



Culvert Repairs

- ◀ **Undermining repair**
 - Repair and installation of toe walls
- ◀ **Invert repair**
 - Concrete paved invert
 - Armor plates
 - Geosynthetic cementitious composite mat
- ◀ **Joint repair**
- ◀ **Footing repair of bottomless culverts**
- ◀ **Relining**

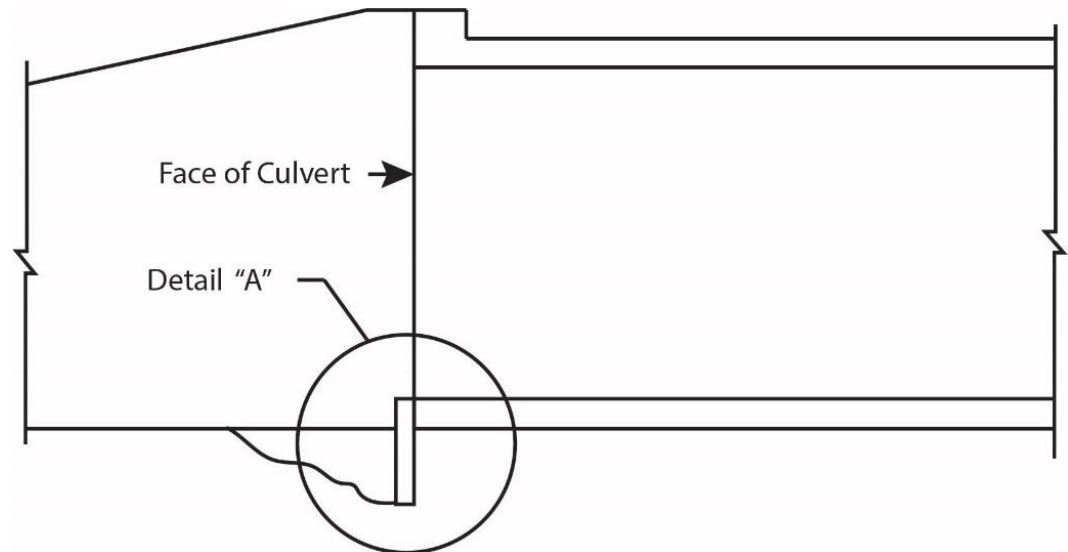
Undermining Repairs > Toe Walls/Cutoff Walls

- ◀ May prevent undermining of culvert in scour prone areas
- ◀ Will not prevent scour holes
- ◀ Must extend below maximum depth of expected scour
- ◀ May be used to prevent piping beneath the culvert



Undermining Repairs > Toe Wall Installation

1. Divert stream
2. Form toe wall
3. Anchor toe wall to culvert
4. Place concrete and cure
5. Backfill with scour resistant material
6. Restore stream

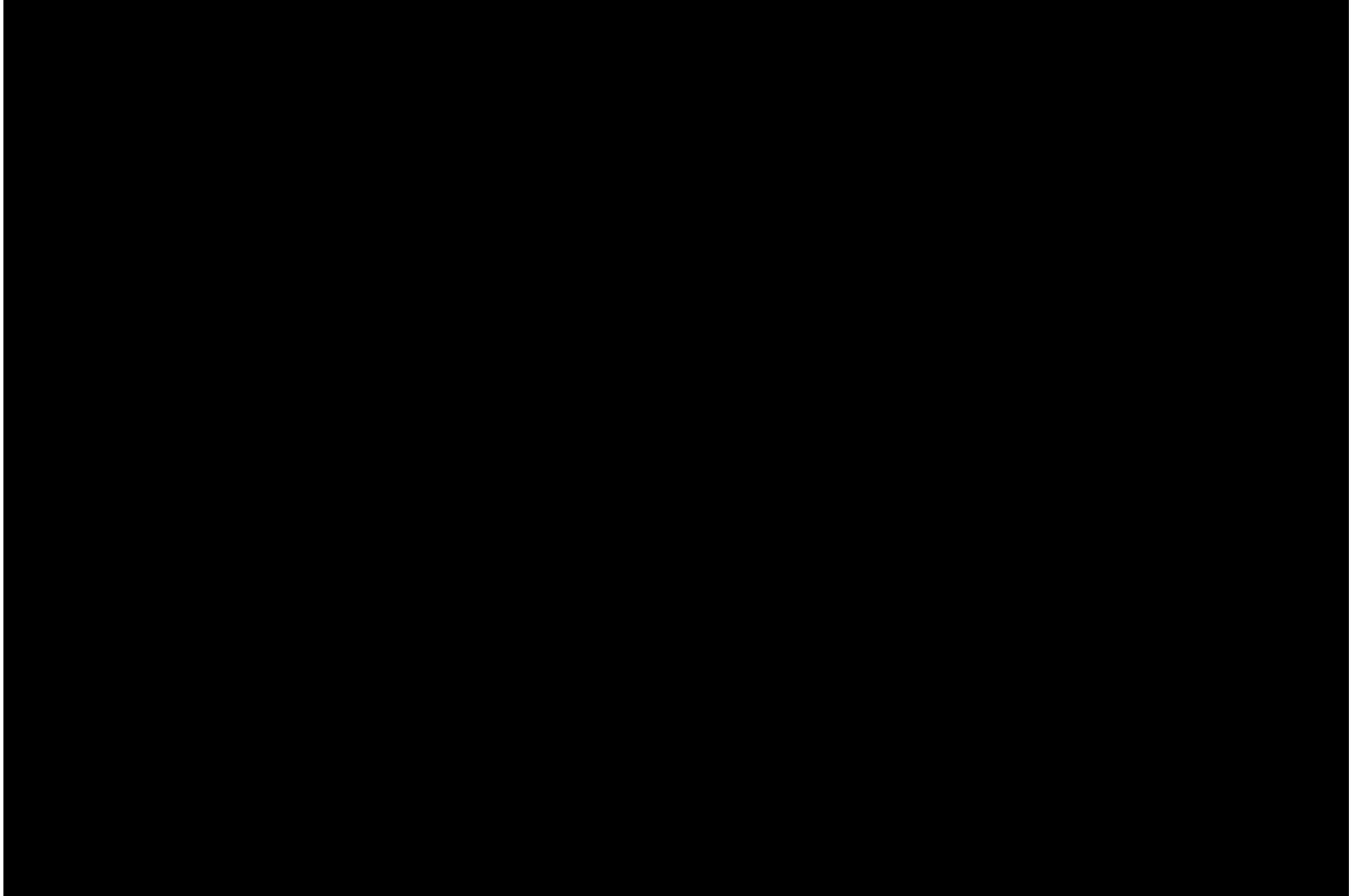


Invert Repairs

- ◀ Concrete Paved Invert
- ◀ Armor plates
- ◀ Geosynthetic cementitious composite mat

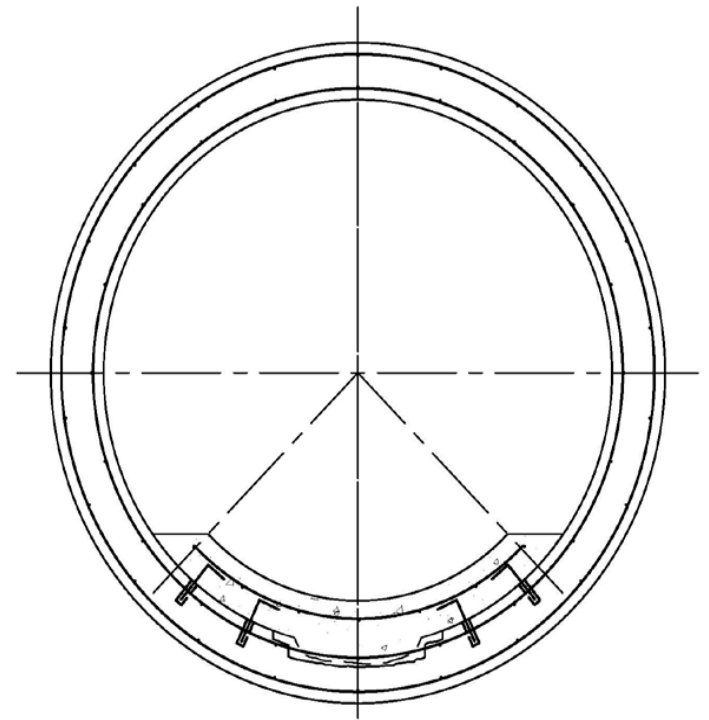


Repair of Damaged Invert Video



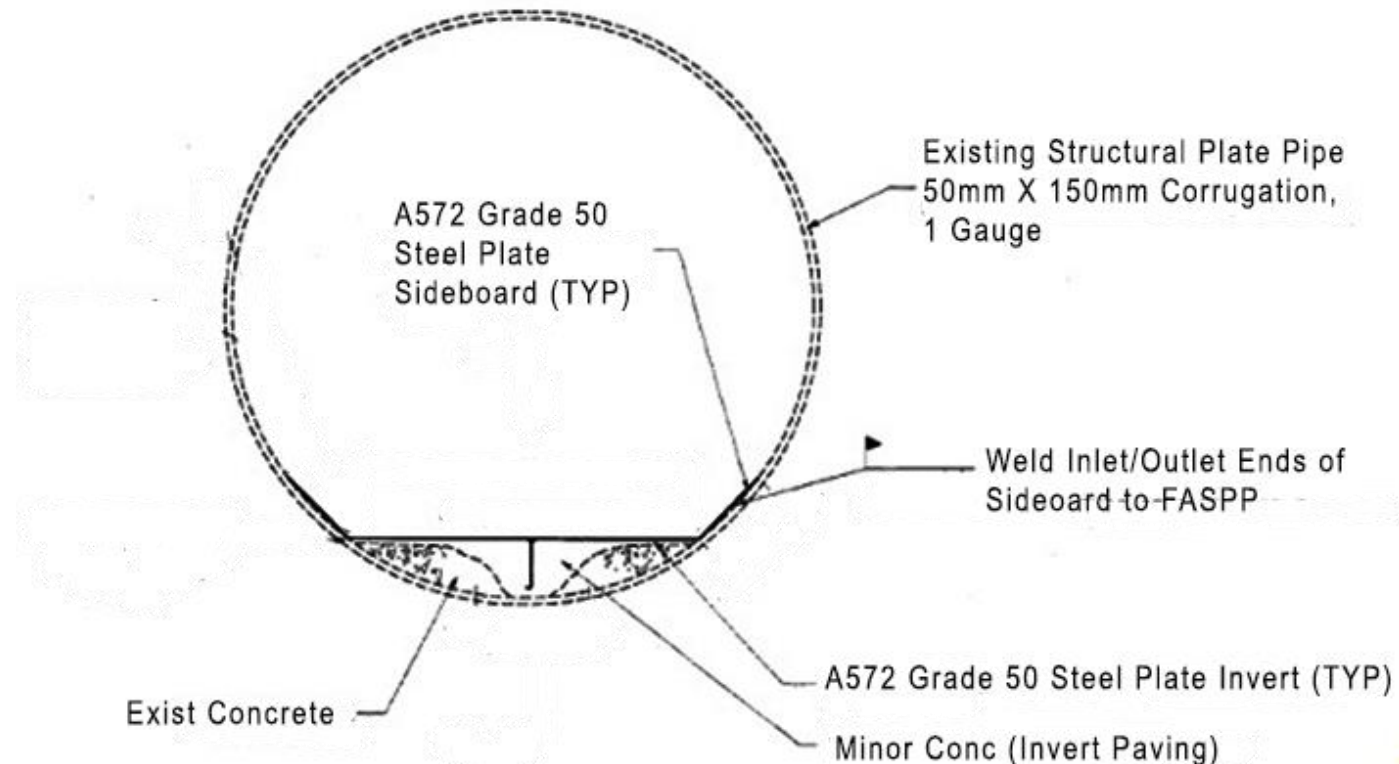
Concrete Paved Invert Repairs

- ▶ Perform stream diversion
- ▶ Clean area of invert to be paved
- ▶ Form and place concrete
- ▶ Cure adequately
- ▶ Restore stream flow



Invert Repairs > Armor Plates

- ◀ For severe abrasion of the invert
- ◀ Spreads flow
- ◀ Resists abrasion



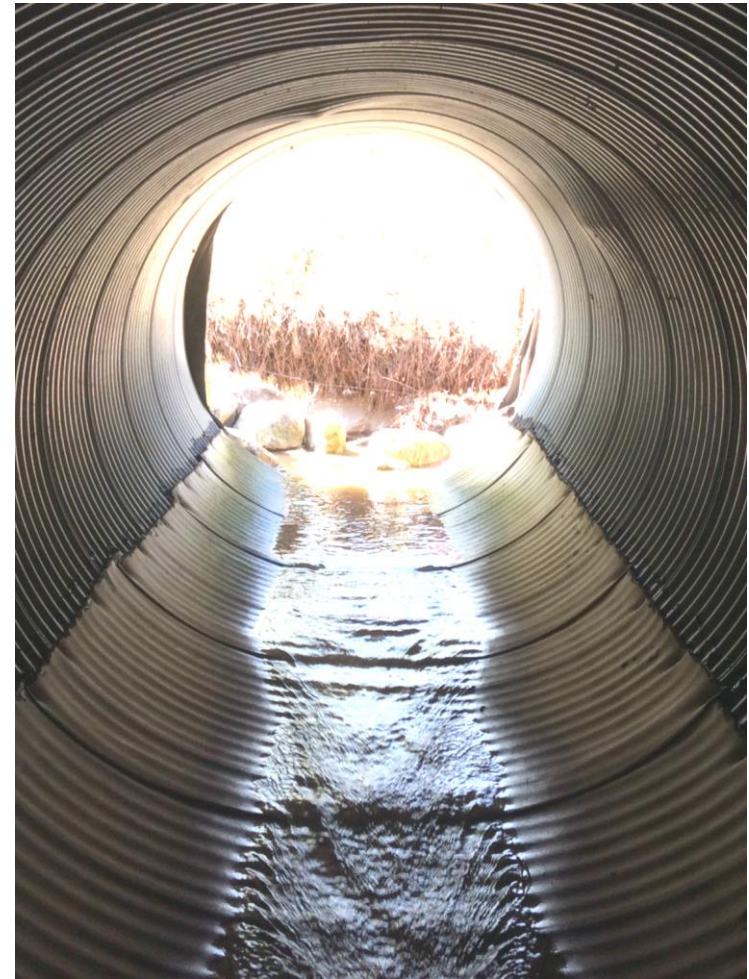
Armor Plates (con.)

- ◀ Important to securely attach plates to host pipe
- ◀ Concrete between armor plate and culvert invert



Invert Repairs > Geosynthetic Cementitious Composite Mat

1. Perform stream diversion
2. Clean area of invert to be paved
3. Place mat in invert in shingle pattern and anchor to culvert
4. Hydrate and cure mat
5. Restore stream flow



Joint Repair Methods

- ◀ Internal bands
- ◀ Flexible chemical grout injection
- ◀ Concrete collars



Joint Repair > Internal Bands

- ◀ Soil tight
- ◀ Does not need to be water tight
- ◀ Bands placed over the joint
- ◀ Tightened into place with threaded rods



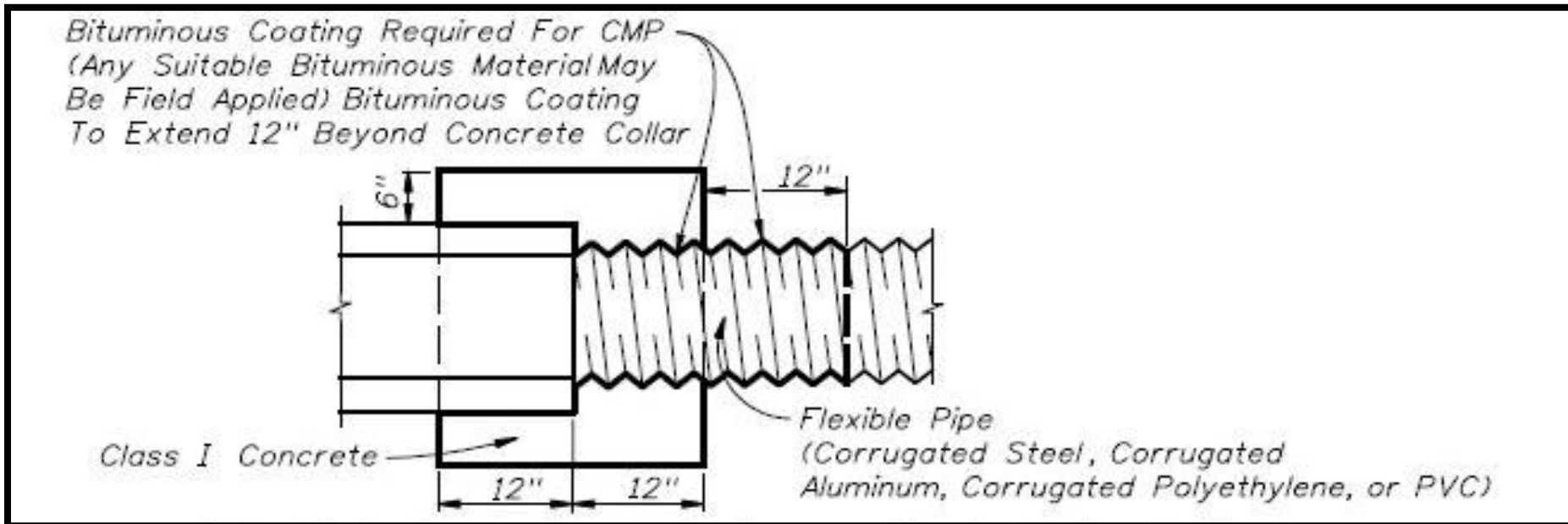
Joint Repair > Flexible Chemical Grout Injection

- ◀ Grout injected through the open joints
- ◀ Grout creates a collar around leaking joint



Joint Repair > Concrete Collar Installation

- ◀ Excavate pipe to expose joint
- ◀ Excavate beneath joint and compact
- ◀ Form area of concrete collar
- ◀ Place concrete and backfill



Relining Culverts

- ◀ Slip Lining
- ◀ Shotcrete and spin cast Concrete Liner
- ◀ Cured-In-Place Pipe (CIPP)



Relining Culverts > Slip Lining

- ◀ Corrugated Metal Pipe
- ◀ Corrugated Metal Plate Pipe/Plate Arch
- ◀ Smooth Interior Metal Pipe
- ◀ High Density Polyethylene Pipe



Relining Culverts > Slip Lining (con.)



(a)



(b)

Relining Culverts > Slip Lining (con.)



(c)



(d)

Relining Culverts > Slip Lining (con.)



(e)



(f)

Relining Culverts > Slip Lining (con.)



Relining Culverts > Slip Lining (con.)

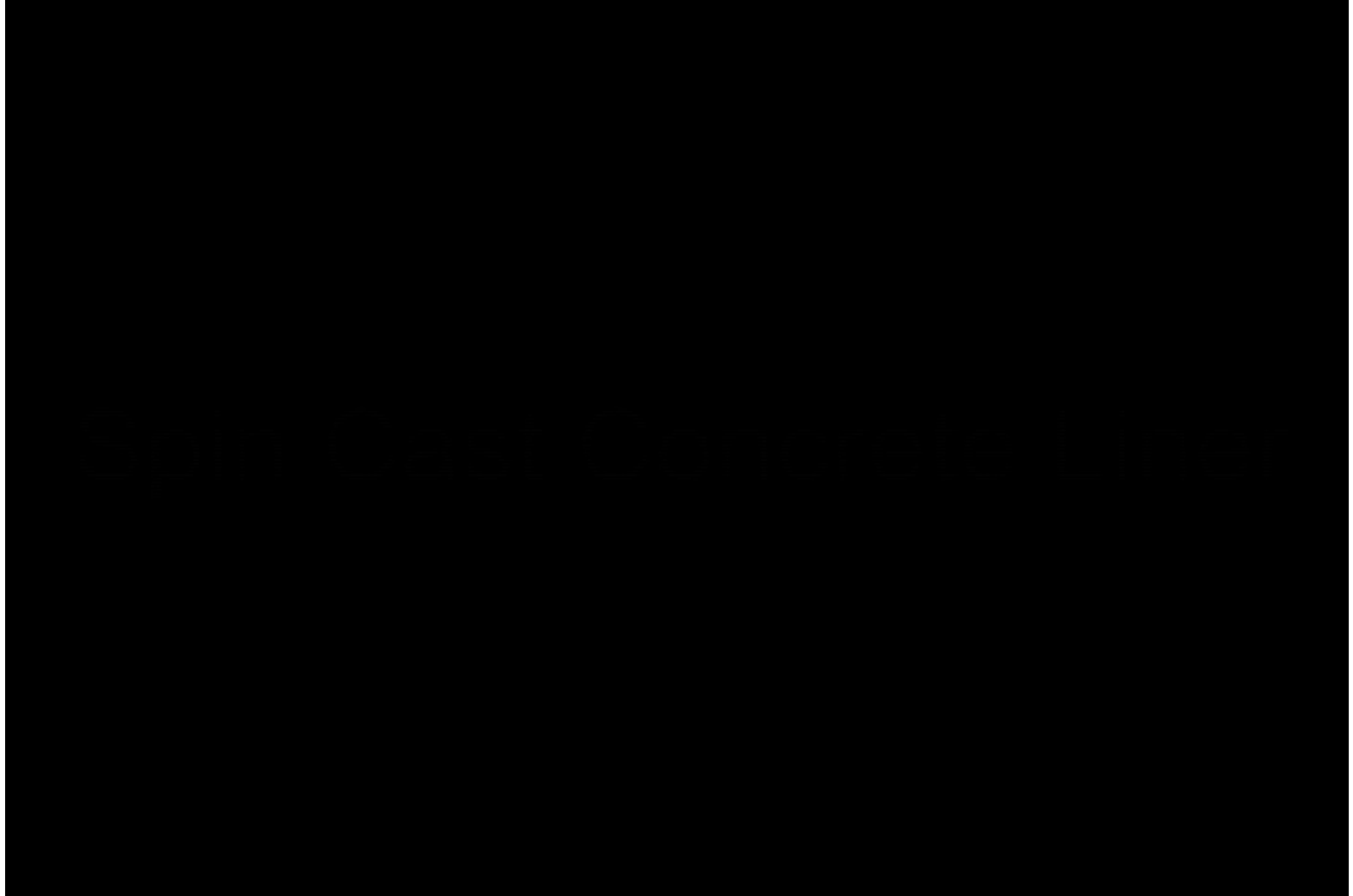


Relining Culverts > Shotcrete & Spin Cast Concrete Liner

- ◀ Concrete interior
- ◀ Liner is uniform thickness over existing culvert
- ◀ Is more forgiving of distortions
- ◀ Cleaning and grouting voids before



Spin Cast Video



Relining Culverts > Shotcrete & Spin Cast Concrete Liner (con.)

- ◀ For larger culverts shotcrete may be used



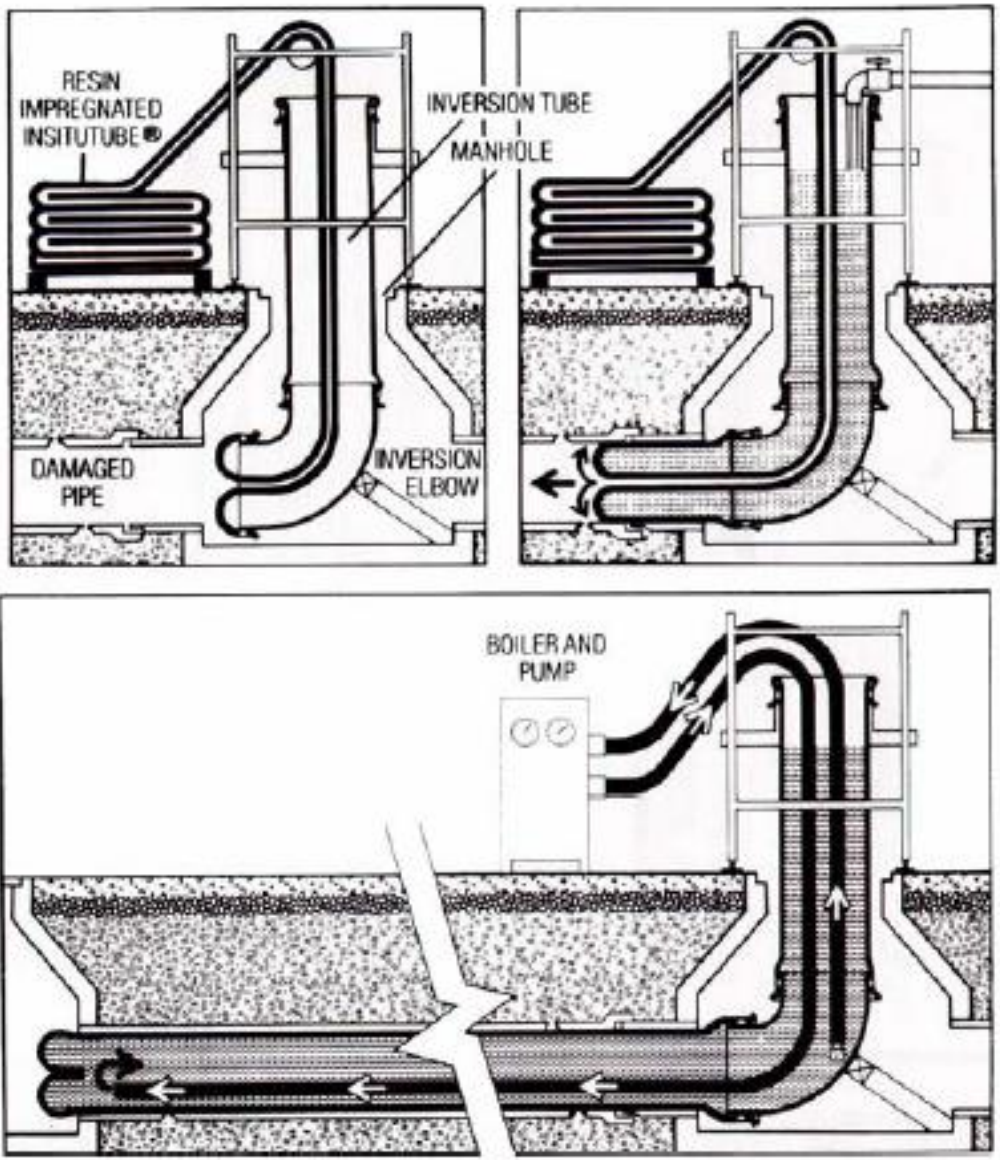
Relining Culverts > Cured-In-Place Pipe (CIPP)

- ◀ Resin Impregnated Felt liner
- ◀ Installed using water or air pressure
- ◀ Cured with hot water or hot air
- ◀ Takes culvert out of service during cure

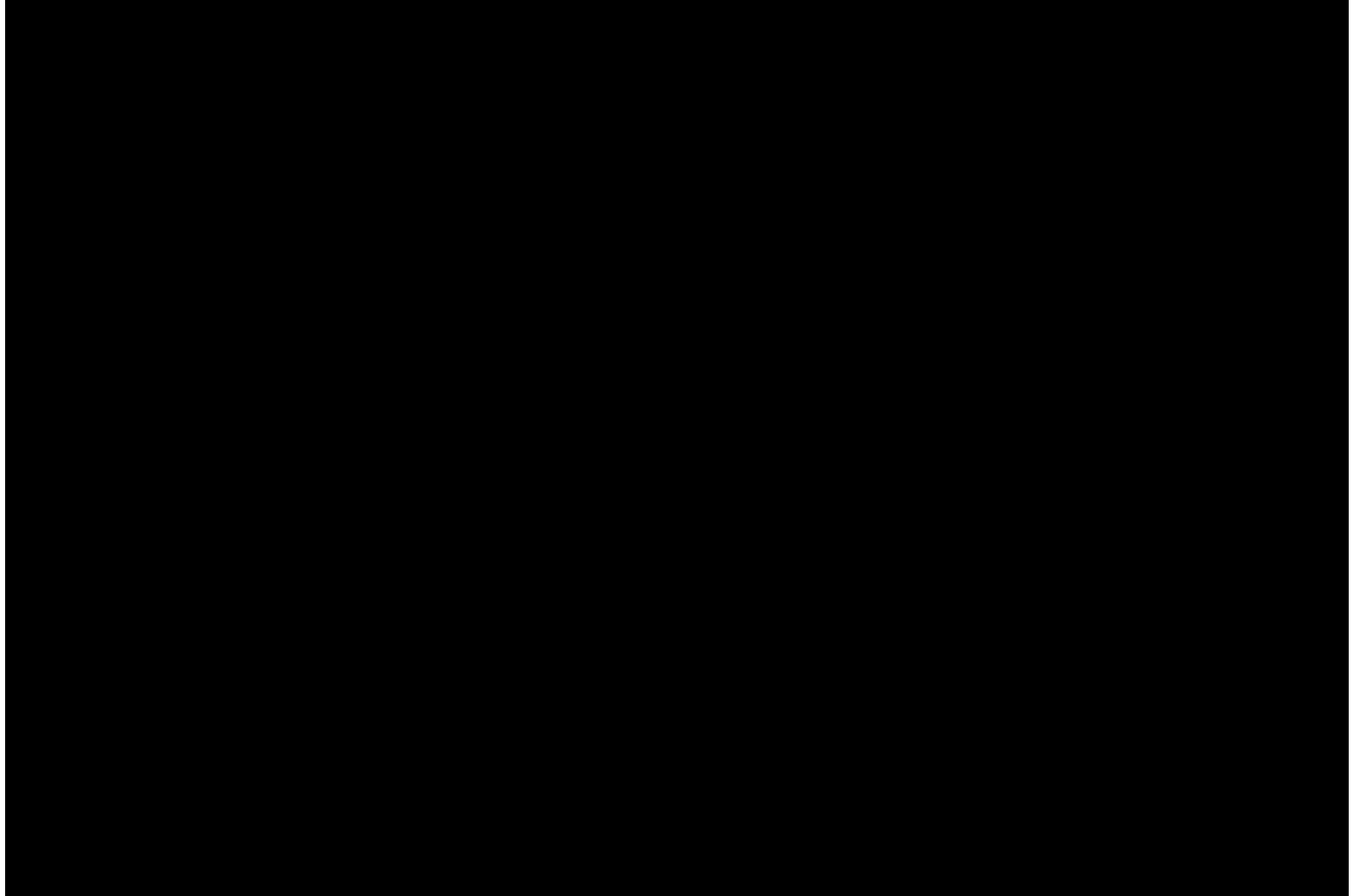


Relining Culverts > Cured-In-Place Pipe (CIPP) (con.)

◀ Inversion or installation process



Installation of CIPP Video



Relining Culverts > Cured-In-Place Pipe (CIPP) (con.)

◀ Inversion Complete



Footing Repair of Bottomless Culverts

- ◀ Similar to concrete pier or abutment repairs
- ◀ Tight spaces making equipment use difficult
- ◀ Stream diversions necessary
- ◀ Assessment of extent of sound concrete needed
- ◀ Extensive repairs may need to extend below scour depth

Footing Repair of Bottomless Culverts (con.)

1. Place coffer dam/bypass pipe
2. Determine extent of repairs
3. Remove unsound concrete
4. Repair reinforcing steel
5. Clean area and form



Footing Repair of Bottomless Culverts (con.)

1. Place bonding agent if used
2. Place concrete
3. Cure concrete
4. Remove forms and re-establish stream



Let's Review

- ◀ Discuss common deficiencies identified in metal culverts
- ◀ Describe preventive maintenance of metal culverts
- ◀ Review repair of metal culverts

Review Questions

Review Question 1

Corrosion in metal pipes can lead to which of the following deficiencies?

- | | |
|------------------------|-----|
| A. Invert Damage | 25% |
| B. Deformation of Pipe | 25% |
| C. Undermining | 25% |
| ✓ D. All of the Above | 25% |

Review Questions

Review Question 2

What would be a preventive maintenance method for prevention of scour?

- A. Placement of riprap or concrete apron 17%
- B. Installation of toe/cutoff wall or revetment 17%
- C. Slip lining or CIPP 17%
- D. Installation of geosynthetic composite mat or armor plate 17%
- ✓ E. A and B only 17%
- F. All of the above 17%

Review Questions

Review Question 3

Which is NOT a viable method for lining a culvert with significant deformations?

- | | |
|------------------------|-----|
| A. CIPP | 25% |
| B. Shotcrete Spin Cast | 25% |
| ✓ C. Slip Lining | 25% |
| D. None of the Above | 25% |

Questions?



Questions



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