Salmon Restoration Federation
2016 Erosion and Sediment Control Workshop

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Thanks, CDFW
Part I
Basics of roads and road system design
Assessing environmental impacts from accelerated erosion and sediment delivery
Evaluating sediment sources for their potential to deliver sediment to streams
Identifying sediment sources and quantifying erosion volumes
Prioritizing road related erosional features for implementation

Part II
Creating erosion control and prevention plans
Top priority upgrading/decommissioning priorities for environmental protection
Choosing the most appropriate treatment options for your road
Performance standards and BMP designs for road upgrading and decommissioning
Environmental permitting application process and requirements

Perhaps ambitious.......
Part 1

- Basics of roads and road system design
- Assessing environmental impacts from accelerated erosion and sediment delivery
- Evaluating sediment sources for their potential to deliver sediment to streams
- Identifying sediment sources and quantifying erosion volumes
- Prioritizing road related erosional features for implementation
Elements of a road
Road Systems
Current and Legacy Impacts of Land Management in Northern California
Impacts to the Eel River Watershed Past and Present

Upslope logging, and rural development
Environmental impacts from poor road construction and maintenance
Some sources and environmental impacts from road systems

- Sediment Delivery to streams
- Disruption of hillside hydrology and alteration of a streams hydrograph
- Fish barriers
- Road encroachment and riparian disturbance
- Road related landslides
Fine sediment discharge
Disruptions to hillside hydrology
most people don’t understand the linkage between roads and water resource availability
Culvert Fish Barrier
Velocity Fish Barrier
Impacts of Dam and Fish Barriers

Free Flowing River at Dynamic Equilibrium

UPSTREAM IMPACTS

- Reduced: Natural Function, Water Quality, Oxygen, Turbid Flow, Circulation, Available Habitat
- Reduced resilience to change
- Increased: Pollutant Accumulation, Stratification, Temperatures, Algae Blooms
- Loss of: Natural Transport Processes of Sediments, Nutrients and Debris
- Self-sustaining Nature

DOWNSTREAM IMPACTS

- Reduced: Water Quality & Riverbed Elevation
- Altered: Flow Regime & Temperatures
- Starved of: Sediment, Nutrients & Debris (habitat building blocks)

Dammed River
Road Encroachment on streams and riparian disturbance
Landslides
Cutbank Debris Slide
Fillslope Debris Slide at Stream Crossing
Debris Slide
Road Slump
Lets revisit the basinwide sediment sources

**Basinwide South Fork Eel Sediment Sources**

- **NATURAL: Earthflows toes and associated gullies**: 38%
- **NATURAL: Shallow landslides**: 11%
- **NATURAL: Soil creep**: 5%
- **Road crossing MW and gullying**: 22%
- **Road surface erosion**: 5%
- **Skid trail erosion**: 2%
- **Shallow landslides, anthropogenic**: 17%
Sediment Production

versus

Sediment Delivery
Non-delivering fillslope landslides
Types of Erosion

- Surface Erosion
- Gully Erosion
- Channel Erosion
- Mass Wasting (landslides)
Soil Pedestals
Rills
Gully Erosion
Landslides
Washed-out stream crossing
Cutbank surface erosion
Hydrologic Connectivity
Fine sediment discharge
Environmental Problems Caused by Roads and Road Management Activities
Roads are “unique”......
Clean water, Clean gravel
Gullies and increased drainage density
Stream Crossing Erosion:
Gullying and Fillslope Landslides
Roads where streams should be: Road Surface and Stream Bank Erosion
Roads and Erosion

- Types of erosion
- Erosion problems caused by roads
  - Road surface erosion
  - Road-related landslides
  - Stream crossing erosion
Road Surface, Cutbank and Ditch Erosion
Road surface erosion is caused by mechanical abrasion and poor road surface drainage...
Sediment delivery occurs where road surfaces and ditches are “hydrologically-connected” to stream channels
Pot holes - poor road drainage
Road Surface Erosion
Road Berms: Outsloped Road
Sediment from seasonal road
Road Surface Erosion
Road Surface Erosion
Road Surface: Mechanical Abrasion
Road Surface Gullying
Road surfaces and eroding cutbanks feed active ditches...
Cutbank Erosion
Ditch Sediment Transport
Ditch Erosion
Ditch Relief Culvert: Gullying
Ditch Relief Culvert: Gullying and Connectivity
Mature, Hydrologically Connected Gully
Ditch Relief Culvert Connectivity
Dispersing Road Runoff: Berms
Road Berms: Crowned Road
Road Berms: Insloped Road
Road Berms: Outsloped Road
Breached Berm and Gully
Road Surface Erosion and Sedimentation
Hydrologic Connectivity
Hydrologic Connectivity of Roadside Ditches
Connectivity of Roads and Ditches
Sedimentation from Ditch
Connectivity from upslope ditch relief culvert
Traffic, fine sediment, and connectivity
Quiet, but common, connectivity
Mature, Hydrologically Connected Gully
Classical Road Drainage Engineering: Connected Road, Cutbank and Ditch
Treated Road - Clean Connectivity

Clean ditch flow

Turbid streamflow
Roads and Erosion

- Types of erosion
- Erosion problems caused by roads
  - Road surface erosion
  - Road-related landslides
  - Stream crossing erosion
Road-Related Landslides:

Cutbank Landslides
and
Fillslope Landslides
Cutbank Slump
Cutbank Debris Slide
Delivering cutbank landslide
Cutbank Slides Generate Spoil
Soil Disposal Practices
Spoil Management Practices and Water Quality
Fillslope Debris Slide at Stream Crossing
Fillslope Debris Slide at Stream Crossing
Fillslope Slump
Potential Fillslope Failure

Cracks
Potential Fillslope Failure
Potential Fillslope Failure

Small scarp
Potential Fillslope Failure

Scarps
Potential Fillslope Failure
Deep Seated Landslide
Deep Seated Landslide
Roads and Erosion

- Types of erosion
- Erosion problems caused by roads
  - Road surface erosion
  - Road-related landslides
  - Stream crossing erosion
Stream Crossing Erosion:

Washouts (Gully) and Stream Diversions
Culverted Stream Crossings
Unculverted Stream Crossings
Unculverted Stream Crossings
Undercut Hardened Ford
“Repaired” Hardened Ford
Armored Fill
“Unofficial” Armored Fill
Ford with soft bottom
Ford with soft bottom
Ford with soft bottom
Ford with connected approaches
Plate Arch (Bottomless-Culvert)
Plate Arch (Poor Orientation)
Bridge (insufficient capacity)
Collapsing Log Stringer Bridge
Reduced channel width
Undercut armor
Fine sediment from approaches
Culverted Stream Crossing
Shallow, Short Culvert
Short Culvert
Short Culvert
Culvert too short...
Plugged Culvert and Pond
Plugged Culvert - Crossing erosion
Washed Out Stream Crossing
Undersized Culvert(s)
Undersized Culvert
Culvert Plugging
Culvert Plugging
Culvert Plugging
Plugged Culvert and Stream Diversion
Stream Diversion Gully
Stream Diversion Gully
Other Culvert Problems:

...too flimsy
...too old
...too shallow
...too short
...too small...
Separated Culvert, Collapsing Fill
Separated Culvert, Collapsing Fill
Rusted-through culvert
Rusted-through culvert
Rusted-through culvert
Culvert is prone to plugging
Undersized Culvert

Headwall scour
Culvert is undersized or plugs

Spoil pile

CMP Inlet
Undersized Culvert and Spoil Disposal

Spoil pile

CMP inlet
Undersized Culverts
Summary of common road related erosion and sediment delivery problems

- Poor choice of road alignment or location

- Hydrologic connectivity from:
  - Upland road surfaces
  - Stream crossing approaches
  - Bare areas related to the road
  - Hillside gully erosion

- Poor stream crossing construction
  - Inadequate bridge installation
  - Culvert undersized
  - Culvert not aligned with channel
  - Culvert not a channel grade
  - Stream diversion potential
  - Culvert high plugging potential

- Road related landslides
Prioritizing road related features for implementation

Considerations:
• Problem types: Fish barrier, stream crossing performance, potential sediment delivery, landslides, chronic erosion
• Likelihood of sediment delivery
• Future volume of sediment delivery
• Biologic importance of receiving waterbody
Part II

Creating erosion control and prevention plans
Top priority upgrading/decommissioning priorities for environmental protection
Choosing the most appropriate treatment options for your road
Performance standards and BMP designs for road upgrading and decommissioning
Environmental permitting application process and requirements
Creating an erosion control and prevention plan for roads and road systems

1) Compile available data for the area of interest
   - Digital terrain models
   - Spatial and temporal distribution of biologic resources
   - Ownership boundaries
   - Historic air photo imagery
   - GIS layers (roads, timber harvests, etc.)

2) Use the available data and landowner input to create a base map with:
   - Road construction history
   - Past land use/disturbed areas
   - Observable historic and current landslides
   - Desired future conditions of roads (upgrade/decommission)
   - Design vehicle information for the roads subject to inventory
Creating an erosion control and prevention plan for roads and road systems

3) Create a project dataform that is specifically designed to capture data on road related sediment delivery sites including:
   - Physical characteristics (past/future sediment delivery volumes)
   - Location
   - Erosion potential
   - Treatment priority
   - Proposed treatment measures

4) Conduct a systematic inventory of the roads, starting at the highest portions of the watershed within which the project is being done

5) Enter the data from the inventory into a database

6) For stream crossing sites
   - Calculate required culvert sizes
   - Estimate road fill volumes from geometric measurements in the field
   - Estimate equipment time to upgrade/decommission the crossing
Creating an erosion control and prevention plan for roads and road systems

7) Add stream crossing data to the database and create a series of tables used to summarize the findings and projected costs of project implementation

8) Compile all data into a GIS database and create maps of the project area
1998 South Fork Garcia River sediment source assessment

4.3 square mile watershed
Road construction history results

30.6 miles of road
7.1 miles of road/square mile
Sediment assessment results

84 stream crossings
Assessment results (cont)

14.3 miles of hydrologically connected road surfaces and ditches
Treat 12.9 miles of hydrologically connected roads:
Total “Streamlined” and “Complete” sediment control cost $80,000

Treatments: Install rolling dips, ditch relief culverts, outslope roads, and selected rocking
Choosing the most appropriate treatment options for your sediment delivery site or road system (There's more than one way to skin a cat)
Choosing the most appropriate treatment options for your sediment delivery site or road system

Each sediment delivery point on a road requires a unique treatment based on the site conditions and the landowners requirements.

For each proposed treatment option you may consider:
- Potential benefits
- Potential limitations
- Likelihood of success (effectiveness)
- Relative costs
- Impacts to current and future road use
- Required future maintenance
Control and prevention of surface erosion

- Minimize bare soil
- Cover bare soil – mulch or revegetate
- Disperse runoff from bare soil areas
- Direct concentrated runoff to vegetation
- Break up bare soil areas into smaller areas
- Disconnect and disperse flow paths (e.g., road surfaces) and ditches
- Feasible Target: ≤10-20% of road network; less on upper hillslopes; abandoned roads ≤ 5%
Recommendations to reduce or eliminate roads as a source of fine sediment:

- Construct **outsloped road shapes** with no berms, and periodic rolling dips, disconnecting crossing approaches,
- Utilize inboard ditches **only** where springs are present along the cutbank, or to collect runoff from upslope,
- Disconnect ditches using frequent ditch drains,
- Minimize ditch grading; revegetate connected ditches
- Avoid through-cut roads & roads down the axis of swales,
- Do not pipe riparian road runoff directly to streams; use **perforated flex pipe** on contour to disperse flow,
- Culvert spacing should result in **no hillslope gullies**,
- Dewater connected gullies, even if they are stable, and
- Construct properly designed and sized **sediment basins**.
Don’t forget….treat the cause and not the symptom of your problem

keep in mind…..every complex problem has a simple solution that doesn’t work.........
Gullies from road surface runoff
Another gully...
Treating the cause by dispersing road runoff
ROAD DRAINAGE TREATMENTS

Road shaping
Road shape conversion

Insloped with ditch, wheel ruts & berm - Gullied with 100% connectivity

Outsloped with rolling dips - No connectivity
Seasonal use roads with outsloped shapes and rolling dips (no berm or inboard ditch)
Road shape conversion

Insloped with ditch – 100% connectivity

Outsloped with rolling dips – No connectivity

before

after
Road outsloping

Driveability, Functionality and Safety

4-5% 

2-3%

flat

super outslope
Treated Road - Clean Connectivity

Clean ditch flow

Turbid streamflow
ROAD DRAINAGE STRUCTURES

Rolling grade, rolling dips, ditch relief culverts and berm breaks
Road with rolling grade
Outsloped roads with Rolling dips

Rural subdivision

Logging haul road
Outsloped with rolling dips – ditch eliminated
Outsloped road with rolling dips – ditch retained

Insloped road with ditch – hydrologically connected
Lead-out ditch or cut drains road rut

Sediment fan
Berm breaks on a fall-line road
DRC – no gully
DRC installation
Full-round downspout
Energy dissipation
Road drainage structures

Vegetated ditch

Ditch relief cmp and downspout

Sediment basin

End cap

Perforated pipes
STREAM CROSSING TREATMENT TYPES
Culvert alignment
Culvert alignment (what’s missing?)
Culvert alignment
Culvert extension and fillslope grade
Fillslope <2:1 ...No outlet armor needed
Fillslope 1½:1 ...Fillslope armored (pit-run)
...Three years later
Armoring inside...

...and outside fillslopes

Standards:
- 2:1 no rock required
- 1½:1 - 50% up fill face
- > 1½:1 - 100% up fill face
Over-rocked fillslope
Armoring bridge abutments
Embedded culvert for fish passage (minimum 20%)
Culvert upgrade: before
Culvert upgrade: after
Culvert upgrade: before
Culvert upgrade: after
Before

Gone fishing...for sediment
After
During
After 1st winter
Energy dissipation
Fill compaction
Bermed fillslope
Emergency overflow culvert
Emergency overflow culvert
Before
After
Emergency overflow culvert
Emergency overflow culvert
Plate arch (bottomless arch)
Ford
Hardened ford
Before
After
After 1 winter
Bridge approach connectivity
Slotted road drain
Road Dip on Bridge Approach
Measures of success

• Road decommissioning
  – Excavated stream crossings exhibit less than 5%, preferably less than 2%, loss of erodible fill volume
  – Lower frequency & delivery from road fill failures
  – Hydrologic connectivity reduced to less than 5%

• Road upgrading
  – Decreased culvert plugging
  – No unexpected stream diversions
  – Lower frequency of stream crossing washout
  – Lower sediment delivery from crossing failure
  – Lower frequency and delivery from road fill failures
  – Hydrologic connectivity reduced to 10% to 20%, or less