Fish Passage and Abundance around Grade Control Structures on Incised Streams in Western Iowa

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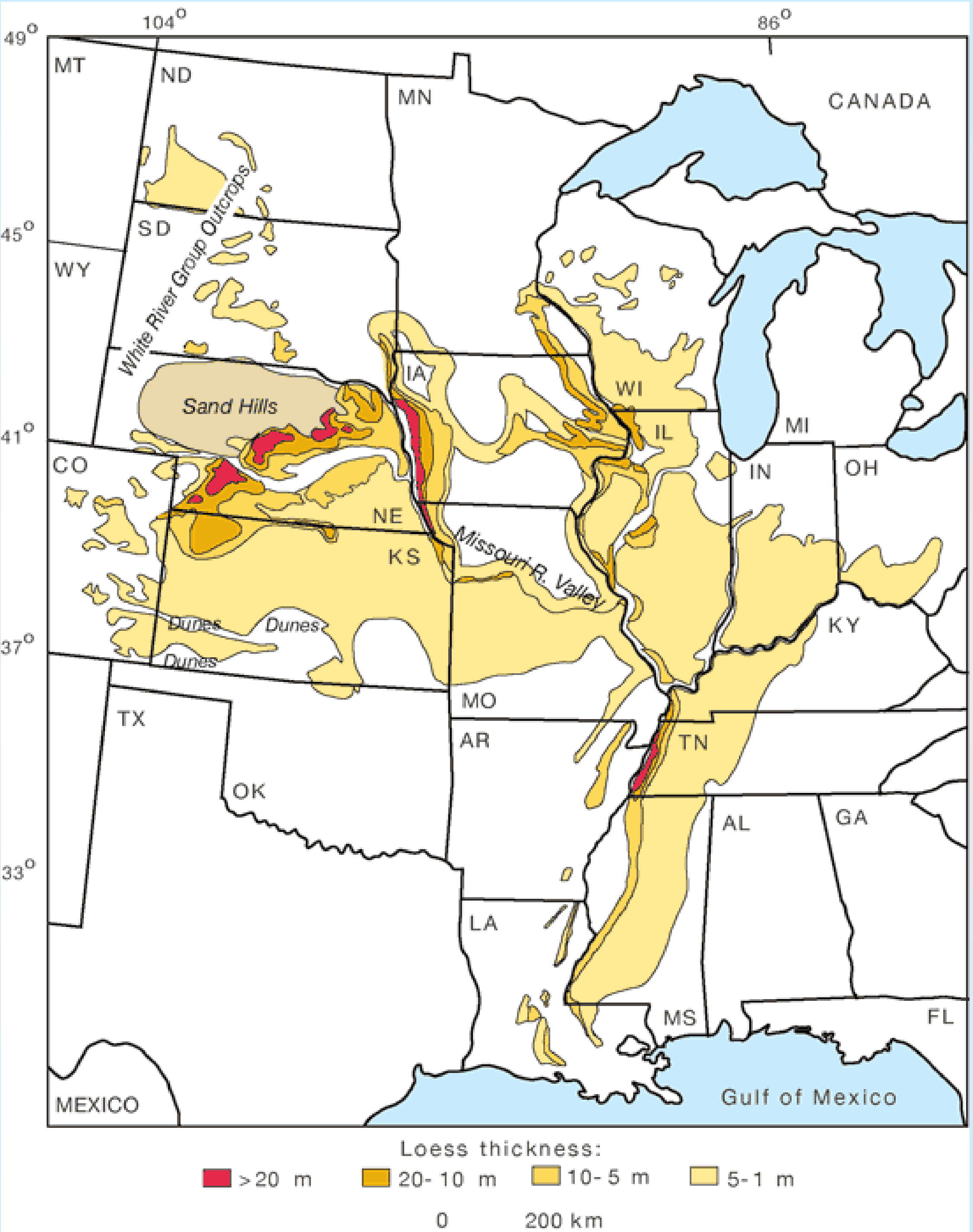
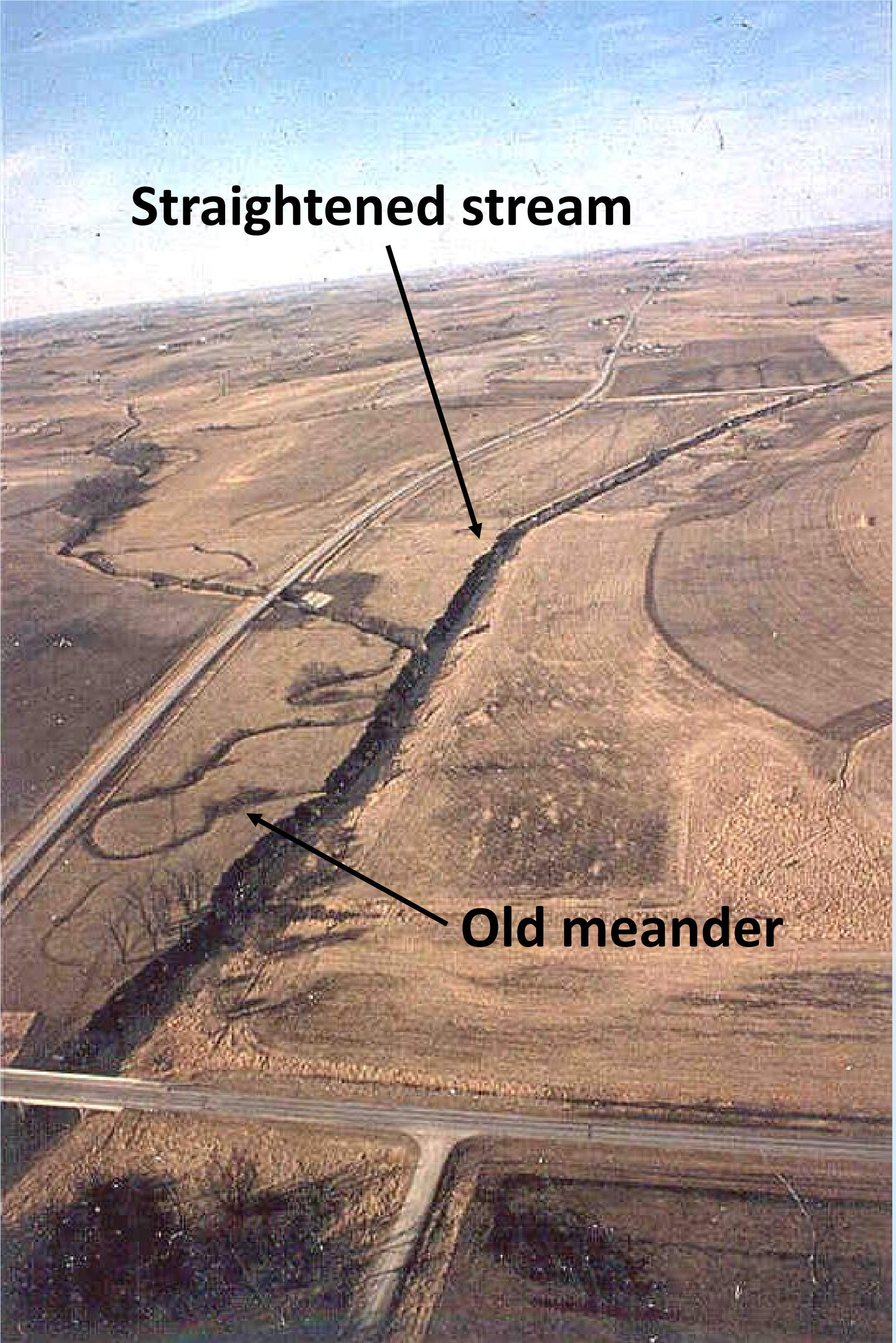


- Loess is a wind blown silt deposit often formed near large rivers.
- Loess is a very erosive streambed material
- Thicker loess deposits = ↑ potential erosion
- MRV loess deposits reach great enough depth (> 5 m) to cause widespread stream channel downcutting and erosion

Excavating a large ditch using steam power, circa 1910.



Highly erodible loess soils

+

Stream straightening and land use changes

=

Higher water velocities

=

Channel downcutting

=

Increased channel erosion

Higher sediment loads

Altered flow regimes

Lost fish habitat

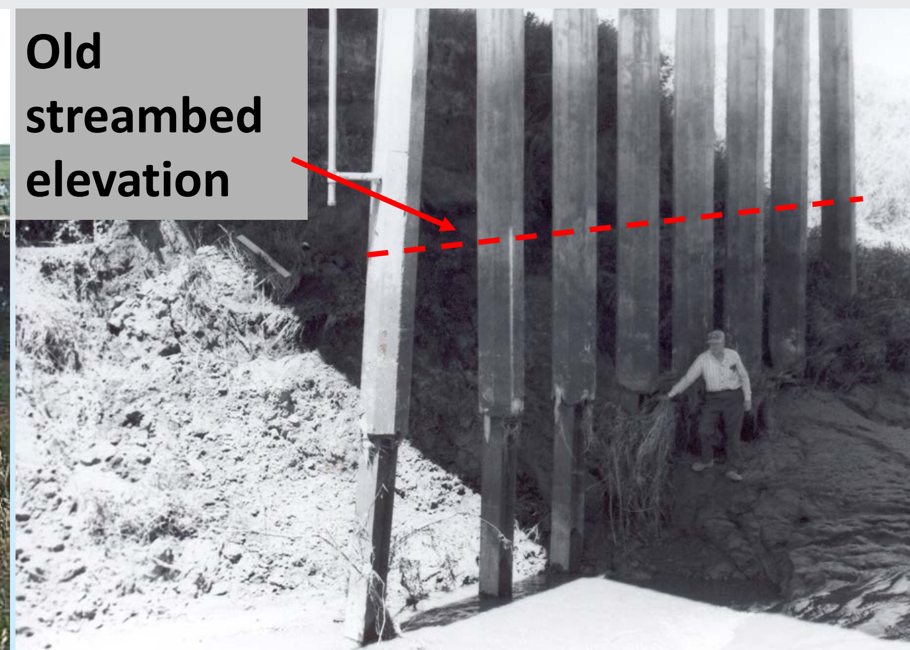
No pool-riffle sequences

Lost lateral connectivity w/ floodplain

Decreased biodiversity

Examples of Knickpoints in Western Iowa

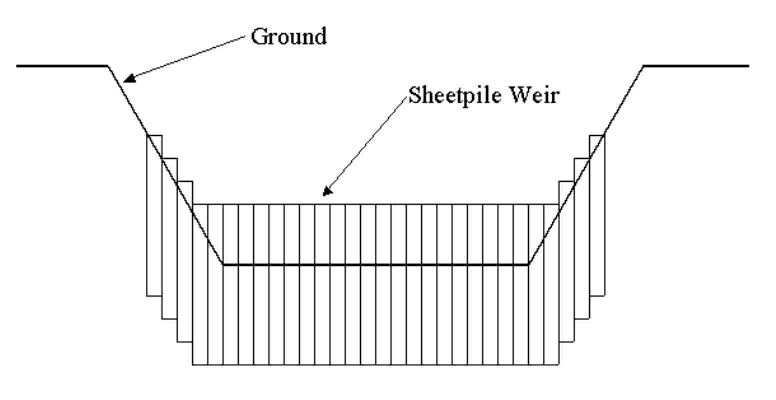
Consequences of knickpoint passage



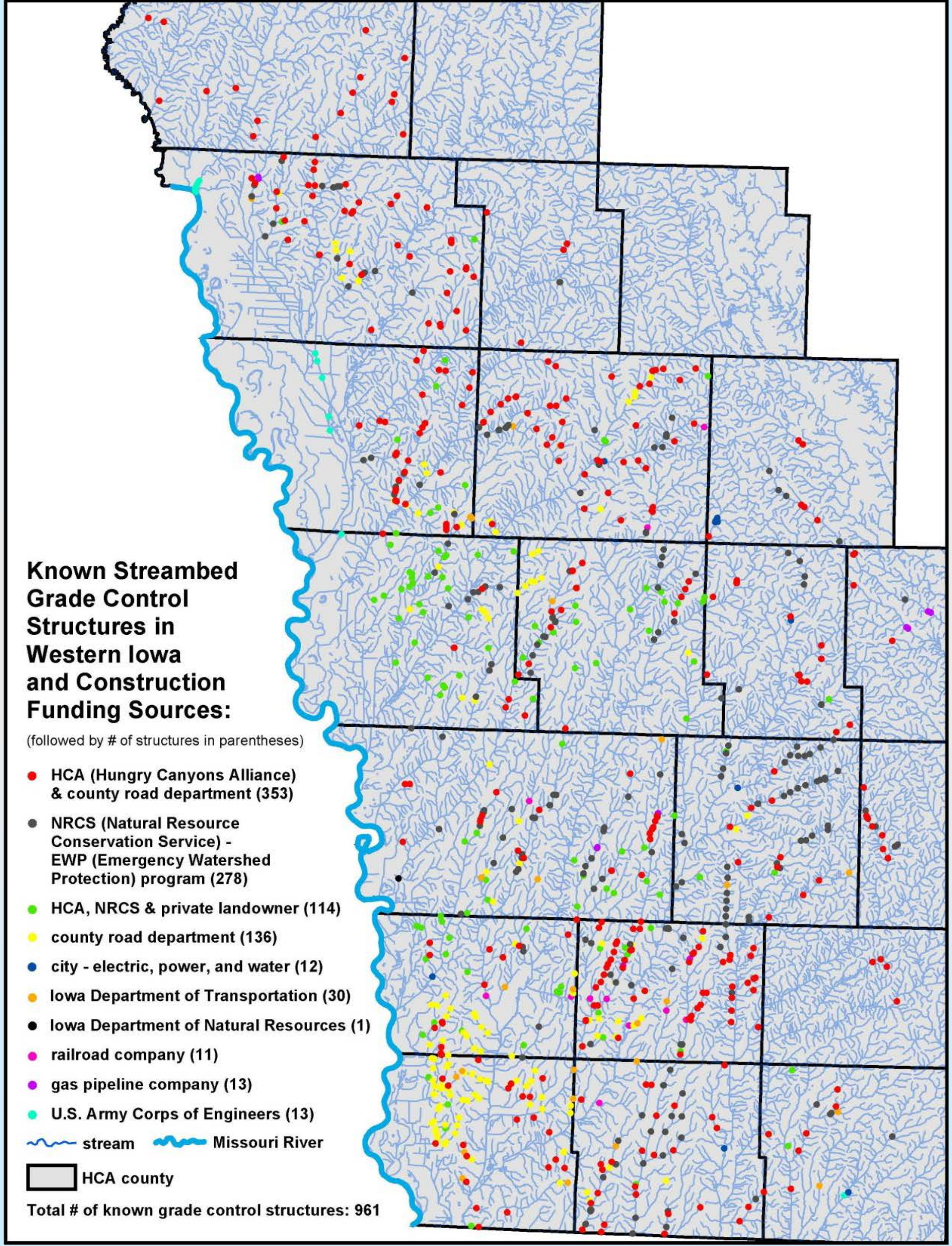
Streambed Stabilization and Watershed Awareness

- Streambed stabilization key to preventing erosion & protecting infrastructure
- Knickpoints affect entire watershed as erode upstream
- Stream videos locate erosion
- Structures at regular intervals change stream profile from erosive steep incline to stable stair-step pattern

Grade Control Structures



- Raised steel sheet pile weir
- Rip-rap, concrete grout slopes
  - Bedrock very poor quality
- Decreases slope of streambed
- Prevents further downcutting
- Creates an upstream backwater condition
  - Sediment settles out upstream
  - Reduces sediment loads
  - Protects bridge pilings
- For <u>every $1</u> invested in GCS:
  - > <u>$4.20</u> in property value (bridges, culverts, utility lines, farmland)
  - ≈ <u>910 kg</u> of soil protected



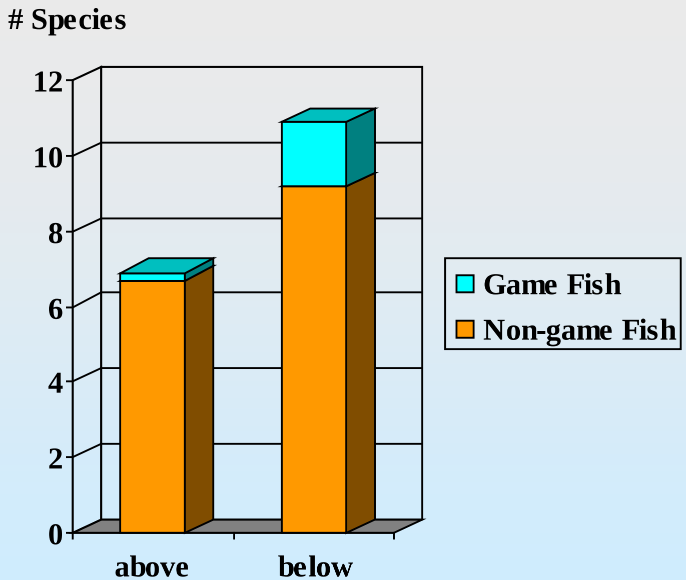
Do GCS affect fish passage, abundance, and longitudinal connectivity?

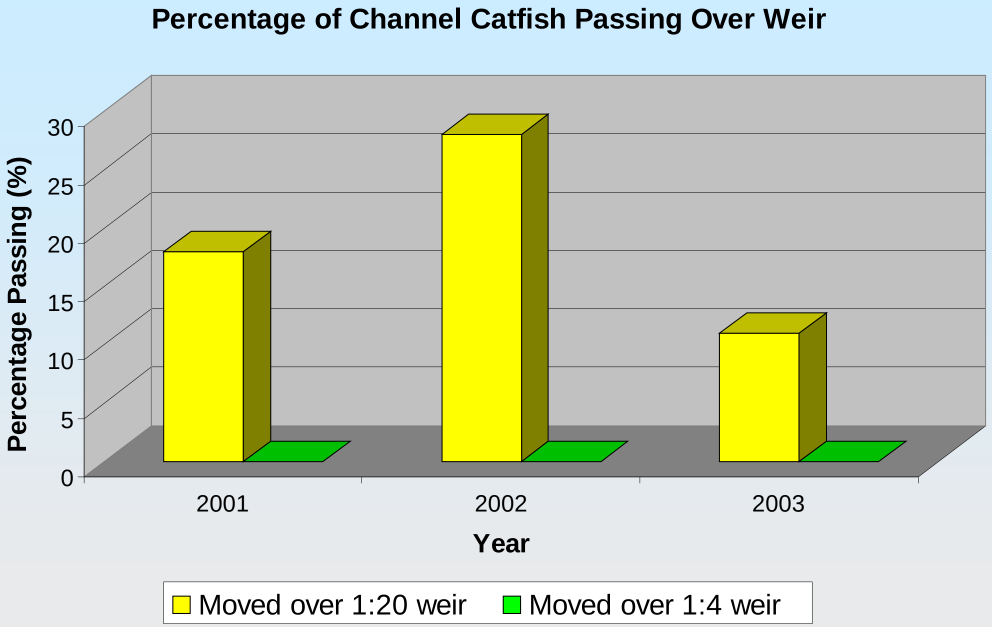
Western Iowa Fish and GCS

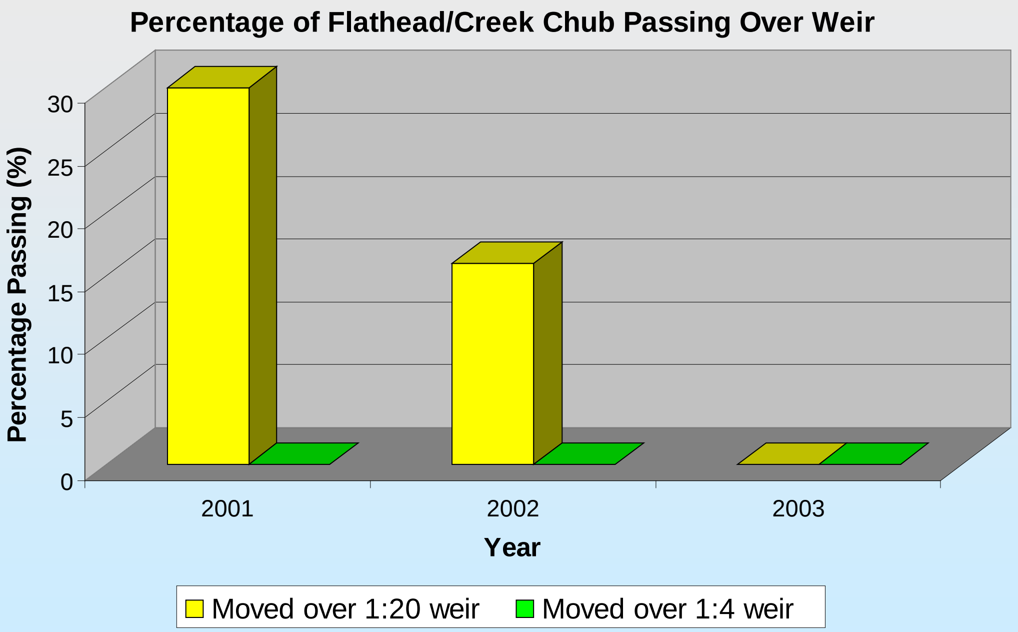
- Warm-water streams – drainages > 400 km^2
- Channel catfish game fish species; flathead and creek chubs non-game fish species
  - All not powerful swimmers
- Sampling efforts and angler reports indicated decline in channel catfish numbers, size and distribution, and species diversity
- Straight drop GCS or steeply sloped GCS
  - Restrict fish movement
  - Loss of longitudinal connectivity
- DNR sampled fish on streams controlled by GCS with 1:20 and 1:4 (rise/run) downstream slopes

Results of First Sampling Study

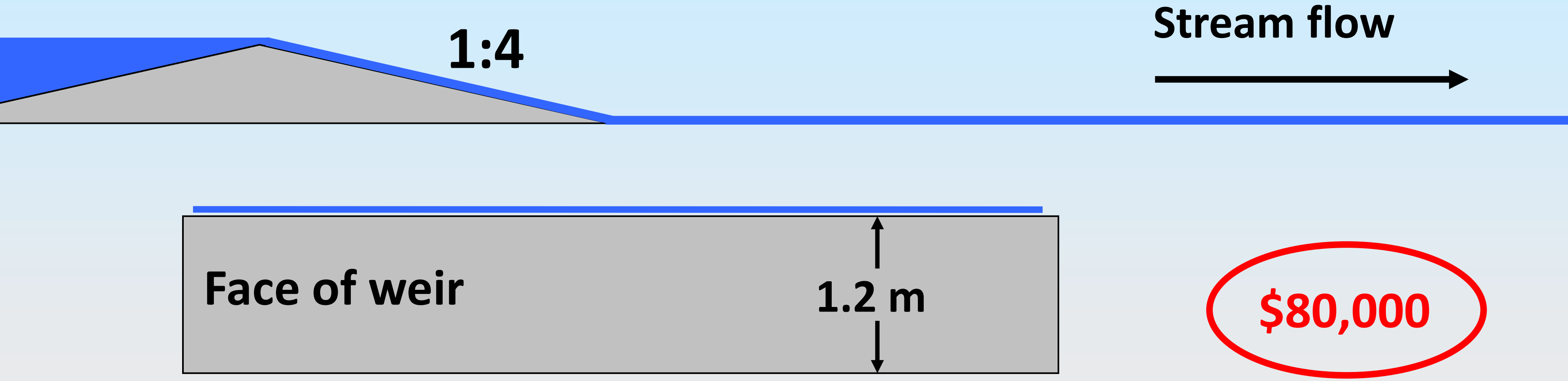
Species diversity and 1:4 GCS



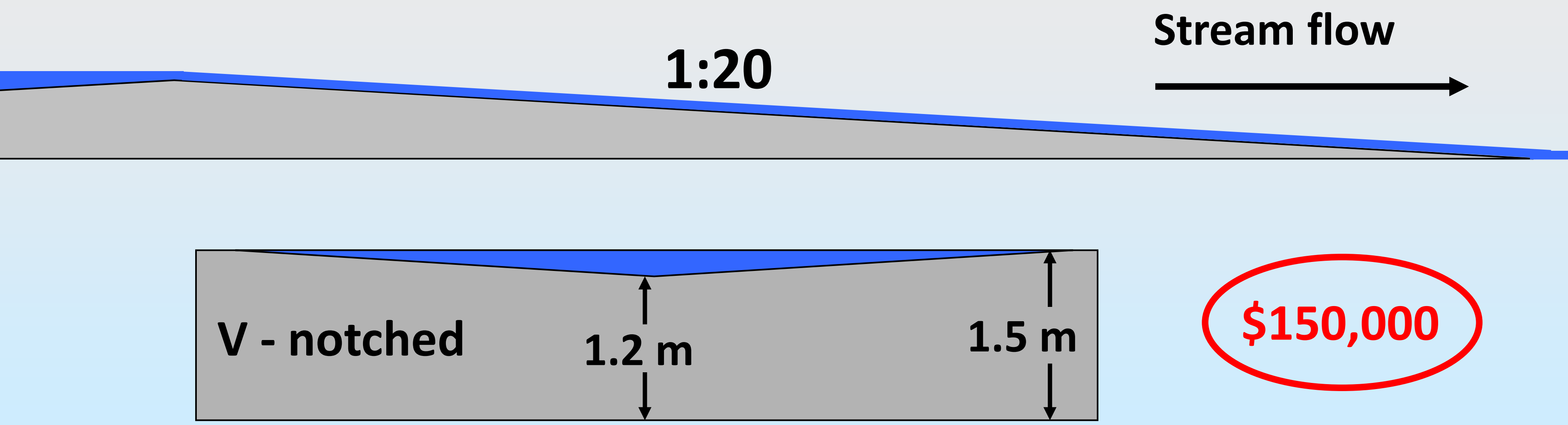




Old Design



Modified Design




GCS designed for fish passage



GCS designed for fish passage



GCS designed for fish passage


What is the steepest weir slope that will allow fish passage?

- Steepest weir slope = least expensive
- Second study to determine optimal slope
  - Sampled fish at 5 GCS with downstream slopes between vertical and 1:20 (rise/run)
    - 3 sites modified during study
  - Macroinvertebrate communities on GCS and at reference sites
    - Sampled 20 sites
      - 5 at GCS
      - 5 upstream GCS
      - 5 downstream GCS
      - 5 reference sites > 1km from any GCS

Results of Second Sampling Study

1. Fish species found tolerant of degradation
2. Little fish passage over weir slopes > 1:12.7
    - 1% recaptured
3. Increased fish passage after modification to ≤ 1:15
    - 16% recaptured
4. Several fish species detected further upstream after modification including channel catfish
5. Significant IBI score increase after modification (4.6 points)

12 metrics of IBI (Index of Biotic Integrity):

1. # native species
2. # sucker species
3. # sensitive species
4. # benthic invertivores
5. % abundance top 3 species
6. % fish as benthic invertivores
7. % fish as omnivores
8. % fish as top carnivores
9. % fish as lithophilous spawners
10. Fish assemblage tolerance index
11. Adjusted catch per unit effort
12. Adjustment for high delt %

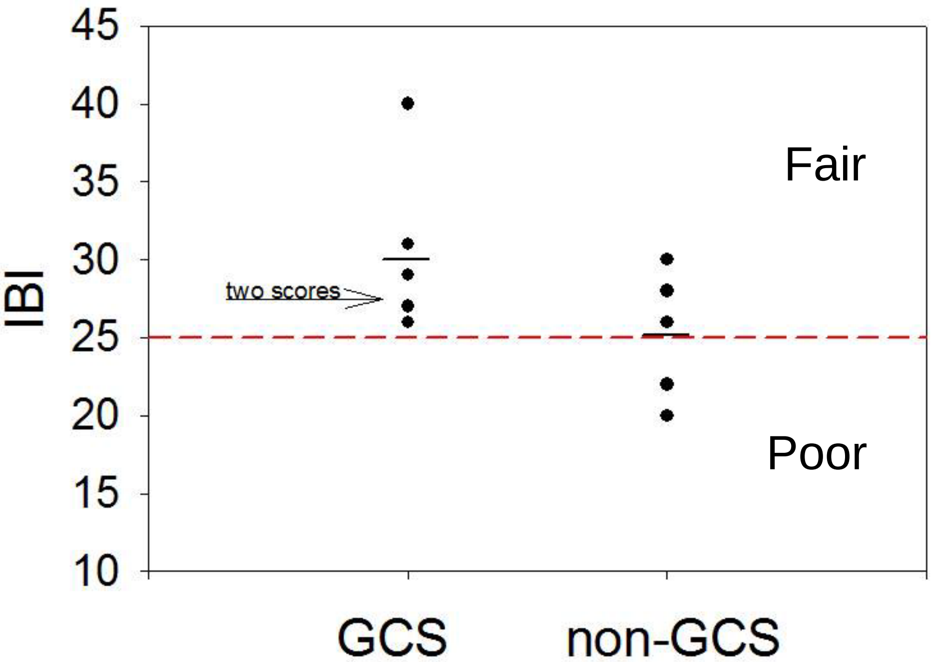
IBI Scores

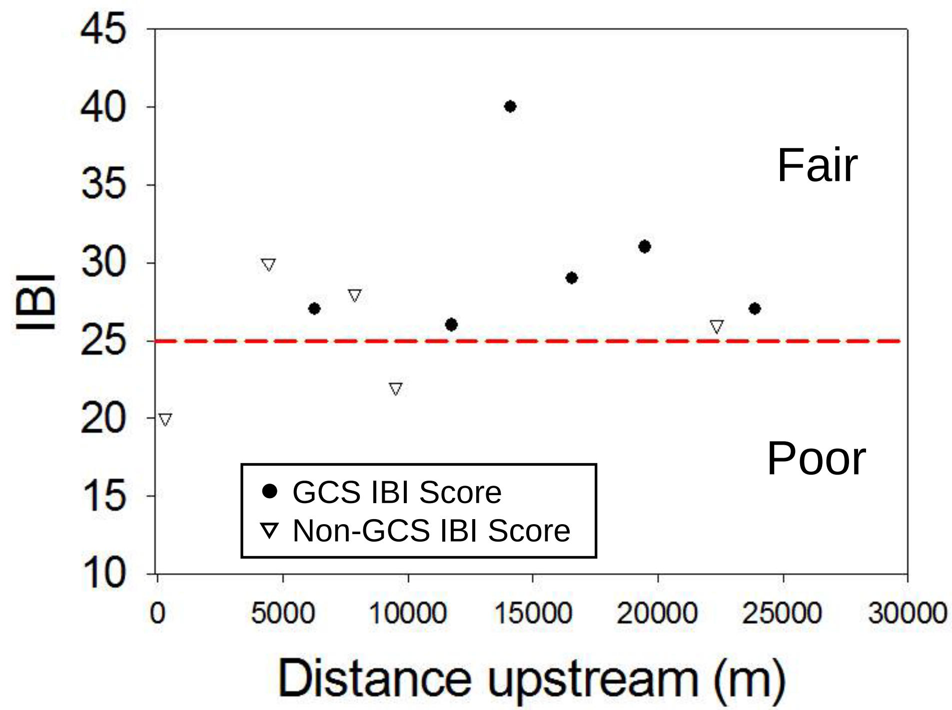
Excellent: 76-100

Good: 51-75

Fair: 26-50

Poor: 1-25

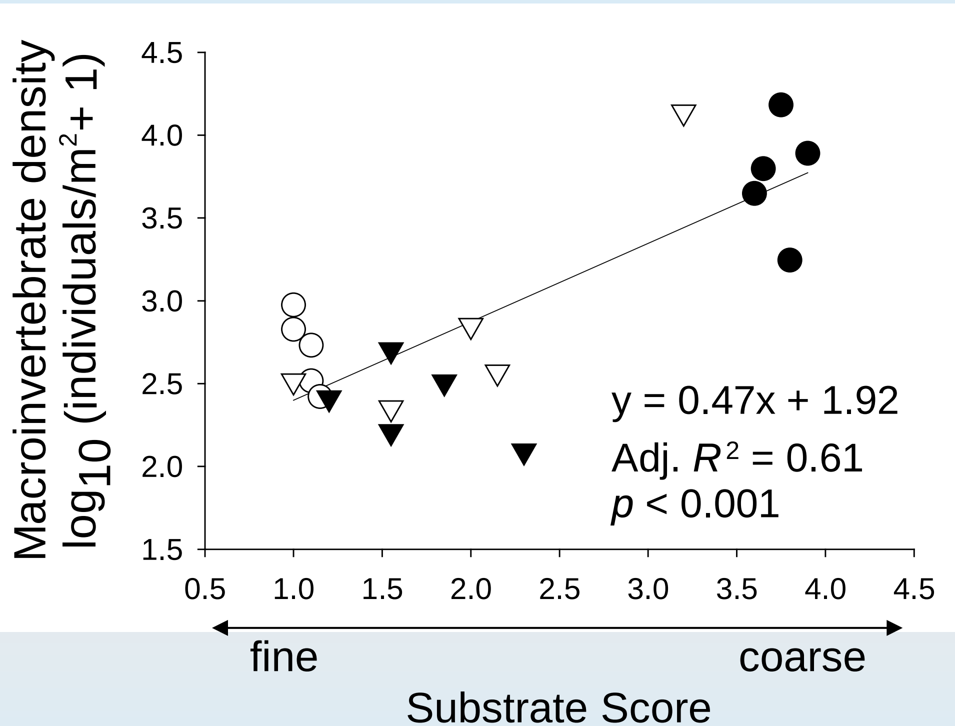




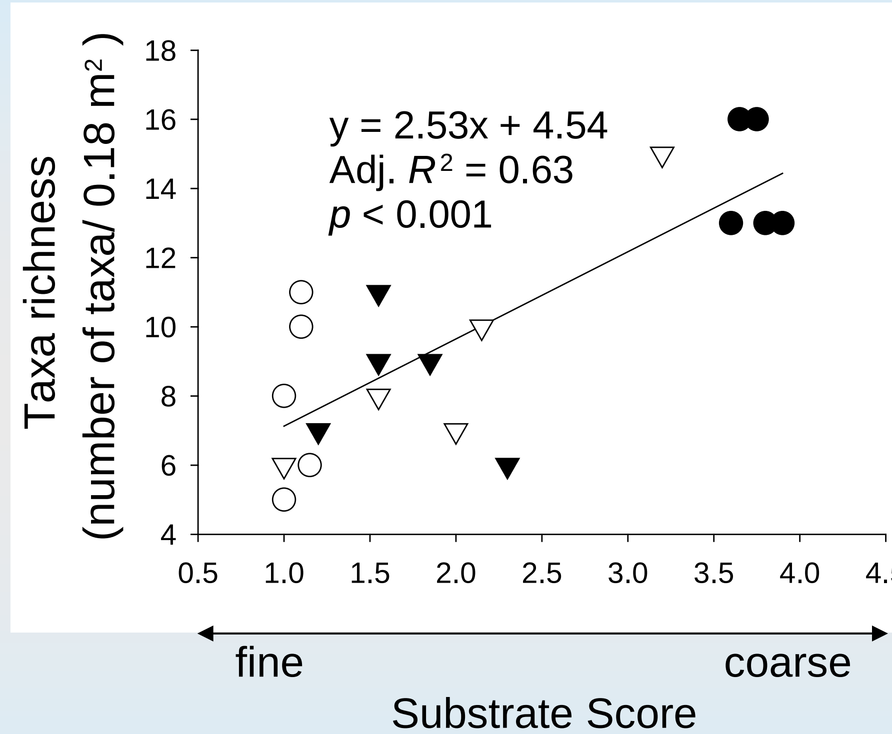
Slightly higher (5%) fish community scores at GCS vs. reaches without GCS

No significant decrease in fish community scores from downstream to upstream

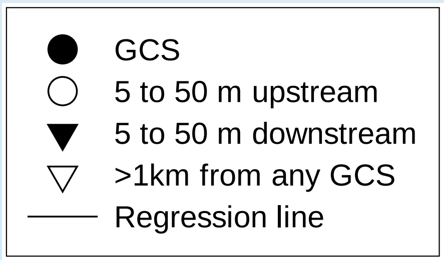
Total macroinvertebrate abundance



Macroinvertebrate taxa richness



Macroinvertebrate abundance and diversity 60% greater at GCS vs. reaches without GCS



Weir Hydraulics Study

- Verification of steepest weir slope allowing fish passage
- Minimum requirements for catfish passage determined by Iowa DNR
  - minimum flow depth of $\geq$ 0.31 m (1ft)
  - maximum flow velocity of $\leq$ 1.22 m/s (4ft/s)
- Sampled 22 GCS
  - 8 riprap weirs
  - 10 grouted riprap weirs
  - 4 fish baffle weirs
  - Ground survey
  - ADV (Acoustic Doppler Velocimetry) measurements
  - LSPIV (Large Particle Image Velocimetry) Measurements

Results of Hydraulic Study

- GCS slope Y (depth) and V (velocity) requirements rarely met
  - minimum depth often violated
  - relatively low flows during the fall of 2004 measuring period
  - mean point flow velocities averaged for each GCS did not violate max. velocity
- No GCS with slopes >1:12 met both fish passage requirements
- 27% of GCS with slopes < 1:12 met depth requirement
  - Of those GCS meeting depth requirement:
    - 60% of 1:12-1:16 met velocity requirement
    - 100% of < 1:16 met velocity requirement
- Fish ladders with baffles formed eddies 30% larger than average catfish fork length of 0.3 m, enough to disorient fish
- Fish ladders observed to catch debris

Now Improving Fish Passage

- Considering studies and economics
  - HCA and DNR agreed – 1:15 grouted weir slopes standard
- Streams classified by fisheries potential
  - Class 0, 1, 2
- Find structure locations on class 2 streams that may not allow fish migration
  - vertical or steep slopes
- Prioritize weirs inhibiting fish passage for modification
  - HCA, US FWS, Iowa DNR funds
  - ≈ 93 structures currently blocking fish passage
  - 37 modified so far

Summary

1. Incised channels
   - Altered flow regime
   - Lateral connectivity loss
   - Biodiversity loss
2. Grade Control Structures (GCS)
   - Prevent further erosion
   - Protect infrastructure
   - Reduce sediment loads
   - Can impact fish passage
3. GCS, fish passage, and biodiversity
   - ≤ 1:15 weir slopes best met minimum requirements to allow catfish passage (≥ 0.31 m flow depth & ≤ 1.22 m/s flow velocity)
   - Higher fish biomass and IBI scores at weirs vs. no weirs
   - Macroinvertebrate abundance and diversity greater at weirs vs. no weirs

Research Partners and Main Reference

- Iowa Department of Natural Resources - Fisheries Bureau
- Iowa Department of Transportation - Highway Research Board
- US Geological Survey
- US Fish and Wildlife Service
- Natural Resource Ecology and Management at Iowa State University
- IIHR–Hydroscience and Engineering Department at the University of Iowa

Thomas JT, Culler ME, Dermisis DC, Pierce CL, Papanicolaou AN, Stewart TW, Larson CJ. 2011. Effects of grade control structures on fish passage, biological assemblages, and hydraulic environments in western Iowa streams: a multidisciplinary review. River Research and Applications **27**:1-10.

Thank You

Any Questions?

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