## APPENDIX B: East Verde River
### Fish Habitat Structure DETAILS

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(Not to Scale)

### East Verde River

List of DETAILS

Preliminary Not For Construction

DESIGN BY: A. Haden, S. Yard

DATE: Nov 2011

REVISION DATE: 

SHEET NO. 1
BOULDER CLUSTERS

Provides overhead cover and creates scour pockets around boulders, builds quiet water resting areas, and sorts spawning gravel.

INSTALLATION NOTES

1. Minimize disturbance to the stream and adjoining areas by scheduling the work when it will interrupt aquatic plants and animals the least.
2. Select stable stream reaches which are not likely to degrade and undermine rock placements.
3. Boulders clusters can be placed along the channel edge and in the middle half of the channel (where deposition is not expected to occur).
4. Boulders can be placed in riffles, runs, flats, glides, and open pools.
5. A suggested spacing of clusters within the same stream segment is one-third of the stream width apart, placed in a manner to break up high velocity flows.
6. Avoid locations where placement could divert the stream channel’s thalweg or threaten impingement on potentially unstable stream banks.
7. Boulders shall be large 1 to 3 ft, irregularly shaped; angular rock locks together better and provides the most hiding spaces.
8. Embed the boulders a short distance into the stream bed in a triangular pattern with spaces between the boulders ranging from 6 in. to 1 ft. This spacing provides cover and other habitat niche needs, and ensures the creation of scour pockets. Top of boulders should be below bankfull elevation.
9. Boulder clusters provide overhead cover and create deep areas which are used by juvenile fish as resting areas.
10. They can restore meanders in channelized reaches, protect eroded banks by deflecting flow, and improve gradation of substrate materials.

Generally, a group of boulders are placed either randomly or selectively, in clusters and/or individually (depending on the pattern of natural boulders in the reach), at strategic points along a channel bed and along the channel fringe. Clusters are located in straight, stable, moderately to well-confined low-gradient riffles (0.5 to 1 slope) for spawning gravel enhancement; they are also placed in higher gradient riffles (1 to 4 percent) to improve rearing habitat and provide cover. At least 1 to 3 foot diameter boulders are recommended, except in very small streams.

This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

<table>
<thead>
<tr>
<th>Source: Stream Corridor Restoration Handbook, USDA. USDA NRCS California Drawing No. CA–NSTR1</th>
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</table>
BOULDER DART
Provides habitat and bank protection, breaks up high velocities along outside of meander and creates small scour holes with verticle cover

DIMENSIONS
D = _______(ft)
L = _______(ft)
B = _______(ft)
W = _______(ft)
WU = _______(ft)
WD = _______(ft)
HU = _______(ft)
HD = _______(ft)

BOULDERS
Dia = _____min(in) _____max(in)
# of rocks per structure ______

1. Bury boulders at ends in substrate and in bank for tie—in.
2. Angle structure upstream at 30 deg. or less sloping from bankfull height or less at 7 deg.
3. Plant willow pole clusters in bank around structure.
4. Dig out downstream side to initiate scour pool development.
5. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

(Not to Scale)

East Verde River

DETAIL:
Boulder Dart

Natural Channel Design, Inc
206 S. Edon St., Flagstaff, AZ 86001
928-774-2338

PRELIMINARY
Not For
Construction

DESIGN BY:
A.Haden, S.Yard

DATE
Nov 2011

REVISION DATE

SHEET NO.
3
BOULDER WING DEFLCTOR

Single wing-deflectors are built to protect a portion of one bank, by deflecting the flow away from the bank. They are also used to create scour by constricting the channel thereby accelerating the flow. Wing deflectors can also create quiet water resting areas for use by upstream migrating spawners.

Opposing wing-deflectors are built to constrict the flow to create a scour pool and sort spawning gravel. These structures are best installed in long, uniform glides or riffles. They create rearing habitat for juvenile fish as well as resting areas for upstream migrating spawners. The upstream side of the deflector will develop deposition that may become suitable spawning habitat.

Opposing wing-deflectors are similar to boulder weirs in that they are keyed into the stream banks, and slope to a low point near the center of the channel. Opposing wing deflectors are created by constructing two single wing deflectors opposite each other, reducing channel width by 40 to 80 percent. They should be constructed in low profile and their apexes should be equal in height.

Wing-deflectors are built in a triangular shape. This configuration will more effectively funnel flows between the apexes of opposing wing-deflectors, or to the apex of a single deflector.

Size of boulders will depend on the size of the channel, but oversized boulders are usually not a problem. If boulders are not big enough or angular enough to resist movement under high flows, it will be necessary to secure them together to create the perimeter of the structure. Smaller boulders or cobble can be used to fill the interior. The stream banks must either be naturally resistant to erosion or bank protection should be incorporated in construction of wing-deflectors.

PLAN VIEW
(Not to scale)

This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.
CROSSOVER LOG
Provides complex habitat, overhead cover and scour

PLAN VIEW
(Not to scale)

GENERAL NOTES
- Log provides shade, overhead cover and creates deeper pool in alluvial streamed.
- Place in straight reach of stream at base of riffle.
- Use large diameter (>12 in) logs with rootwads and top limbs intact when possible.
- Place log perpendicular to flow to create scour in center of stream beneath log.
- Log will create complex habitat around log ends.
- Not to be placed near or upstream of permanent infrastructure since log may shift during high flows.

This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

East Verde River

DETAIL: Crossover Log

Preliminary Not For Construction
**CROSS-VANE WEIR**

Channel pool conversion, grade control, floodplain backwatering and fish habitat enhancement.

**PLAN VIEW** (Not to scale)

**SECTION** (Not to scale)

**PROFILE VIEW** (Not to scale)

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**DIMENSIONS**

<table>
<thead>
<tr>
<th>CW</th>
<th>H</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>HA</td>
</tr>
<tr>
<td>KW</td>
<td>HW</td>
</tr>
<tr>
<td>L</td>
<td>B</td>
</tr>
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</table>

**BOULDERS**

Dia = min(in) max(in)

# of rocks per structure ______

**GENERAL NOTES**

1. Feature provides backwater to increase localized water table for hydric vegetation recovery on floodplain.

2. Weir crest invert set at ordinary high water elevation.

3. Constructed of rock & gravels, providing both fish passage and habitat.

4. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

---

**East Verde River**

**DETAIL:**

Cross-Vane Weir

Preliminary Not For Construction

**Design By:**

A. Haden, S. Yard

**Date:**

Nov 2011

**Revision Date:**

* SHEET NO.

6
GENERAL NOTES

Digger logs are placed with one end anchored on the bank and the other end plunging into the bottom of a pool. Primary use of digger logs is to enhance pool habitat by creating diverse overhead cover for rearing juveniles as well as cover for migrating adults. They are also used to scour the channel, creating or expanding pool habitat. Logs with root wads intact should have the root wad end extending down into the pool to offer the most complexity for increasing rearing habitat and maximizing scour.

Digger logs are usually set in a trench dug into the stream bank. At least one-third of the length of the log should be placed in the bank. This end of the log is covered with boulders to anchor the structure. In the absence of boulders, cobble filled gabions can be used.

If the bank is bedrock, the log may be set on bedrock and held in place using cable and polyester resin adhesive. The log must be anchored in at least two places to keep it secure during high flows. If the digger log is to successfully create scour, it is important that the end of the log in the water does not float during high flows. Digger logs will usually be positioned to point downstream, although there may be some situations where pointing them upstream would be appropriate (where the intention of the log placement is to create scour). The vertical angle of the log should usually be 30 to 45 degrees to the bank.

This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

SOURCE:
USDA NRCS California Drawing No. CA—NSTR2

(Not to Scale) East Verde River

DETAIL
Digger Log

PRELIMINARY
Not For Construction

DESIGN BY: A. Hadens, S. Yard
DATE: Nov 2011
REVISION DATE:
SHEET NO.: 7
**K-Dam**

**DIMENSIONS**
- W = _______(ft)
- L1 = _______(ft)
- L2 = _______(ft)
- W = _______(ft)
- E = _______(ft)
- NW = _______(ft)
- D = _______(deg)
- DL = _______(ft)
- DN = _______(ft)

**LOGS**
- Species ____________________
- Dia = ____ min(in) ____ max(in)
- L = ____ min(ft) ____ max(ft)

**NOTE:** boulders not shown in this view

---

**East Verde River**

**DETAIL:**
- K-Dam

**PRELIMINARY NOT FOR CONSTRUCTION**
LOG BARB

Provides overhead cover with pool scour and bank protection

boulders to anchor and provide ballast on upstream side

< 1/3 channel width

Angle log 30 deg. or less to bank

upstream end buried in substrate of channel

end of log buried in bank

scour pool

PLAN VIEW
(Not to scale)

W

L

BS

BB

E

W = _______ (in)
D = _______ (in)
L = _______ (in)
BS = _______ (in)
BB = _______ (in)
E = _______ (in)

LOGS
Species __________________________
Dia = _____ min(in) _____ max(in)
L = _____ min(ft) _____ max(ft)

BOULDERS
Dia = _____ min(in) _____ max(in)
# of rocks per structure _______

GENERAL NOTES
- Provides bank protection and fish habitat features.
- Use in less steep reaches or run/pool sections in steeper reaches.
- Should be placed on outside of meander to slow velocities at outside of turn.
- Fine sediment should be deposited on upstream side and small scour hole should be created on downstream side with overhead cover created by log.
- In streams with coarse substrate, excavate scour hole during installation and let the stream maintain feature rather than wait for it to develop.
- Use in conjunction with willow pole plantings to further strengthen banks and provide shade and cover to habitat feature.
- Bury one end of log in substrate and the other in bank. Angle log upstream at 30 deg. or less sloping from bankfull height or 2 to 7 %. A duck bill anchor may be added if needed.
- Logs can be held in place by existing trees on bank or large boulders in the stream if excavation not possible.
- Place boulders on upstream side to anchor ends and provide ballast.
- Dig out downstream side to initiate scour pool development.
- This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

East Verde River

DETAIL: Log Barb

Preliminary Not For Construction

Design by:
A. Hadef, S. Yard

Date:
Nov 2011

Revision Date:

Sheet No.
9

Natural Channel Design, Inc
206 S. Elder St.
Flagstaff, AZ 86001
928-774-2336
Log Overhang Structure

**Materials**
1 ea 12 to 16in dia X 15ft log
2 ea 10 to 12in dia X 10ft log
6 ea NO. 2 gripple fasteners
Ballast Rock

*support logs buried in bank*

*varies*

*ballast rock*

*varies, 15 ft max*

*install boulder cluster in stream to break up velocities along log*

**PLAN VIEW**
(Not to scale)

*base flow*

~ 15 ft

**FRONT VIEW**
(Not to scale)

~ 10 ft

**SIDE VIEW**
(Not to scale)

**GENERAL NOTES**
- Install along the outside of bend with higher banks.
- Excavate trenches for footer logs down to stream bottom elevation without disturbing bank at center of structure. Set footer logs so they extend the width of top log into the stream.
- Notch top of footer logs with chainsaw to accommodate top log.
- Set top log and anchor to stream bank with gripple fasteners.
- Pin logs together and into substrate with 5/8 rebar, bent at top.
- Fill footer trenches and place ballast rock between top log and bank, and at ends of structure.
- Regrade and replant bank with native vegetation.
- Boulder clusters can be placed in stream in front of structure to break up current.
- This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

(Not to Scale)

**East Verde River**

**DETAIL:**
Log Overhang Structure

**Preliminary Not For Construction**

**DESIGN BY:**
A.Haden, S.Yard

**DATE**
Nov 2011

**REVISION DATE**
*

**SHEET NO.**
10
MINI WEIR
Creates flow and depth complexity and vertical cover

DIMENSIONS
W = ________ (ft)  BL = ________ (ft)
D = ________ (ft)  BR = ________ (ft)
L = ________ (ft)

FOOTER ROCKS
Dia = ___ min(in) ___ max(in)
# of rocks per structure ______

OTHER ROCKS
Dia = ___ min(in) ___ max(in)
# of rocks per structure ______

PLAN VIEW
(Not to scale)

PROFILE VIEW
(Not to scale)

CROSS SECTION VIEW
(Not to scale)

GENERAL NOTES
- Used to create small pockets of streambed scour and vertical cover in midstream areas.
- Should be placed to provide cover during baseflow periods with no dimensions greater than bankfull elevation.
- Excavate scour hole at installation to initiate habitat formation.
- Install in clusters randomly spaced through riffle and run habitats.

- This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

(Not to Scale)

East Verde River

DETAIL:
Mini Rock Weir

Preliminary Not For Construction

DESIGN BY:
A. Haden, S. Yard

DATE
Nov 2011

REVISION DATE

SHEET NO.
11
POLE PLANTING DETAIL
(Not to scale)

POLE PLANTINGS

POLE CLUSTER DETAIL
(Not to scale)

GENERAL NOTES

PLANT MATERIAL PROCUREMENT and HANDLING

All woody species shall be native and collected from designated local sources.

Dormant unrooted hardwood cuttings can be taken after leaf fall and before bud burst in the spring. Never remove more than 1/3 of any single donor plant during harvesting. The best rooting success is from cuttings that are disease-free, green plants that are 2–10 years old. The best diameters for pole planting, vertical bundles, and trenches are 1/2 to 1 inch and 2 to 3 inches for post plantings. Cutting length varies depending on the application. It shall be long enough to reach 6 to 8 inches into the lowest water level of the year and high enough to expose at least two to three buds.

Cuts shall be made with clean, sharp tools. The bottom end of the stem cutting shall be cut to a 45-degree angle and the top end shall be cut square across or horizontal to the stem. Trim off all side branches and the terminal bud (bud at the growing tip) so energy will be rerouted to the lateral buds for more efficient root and stem sprouting. Do not trim terminal bud from cuttings for vertical bundles and willow trench until after planted. Trimmed tip ends shall be sealed by dipping in light-colored latex, water-based paint.

Submerge cuttings in water for 3 to 7 days prior to planting to maximize water retention. Do not allow the roots to emerge from the bark.

POLE PLANTINGS and POLE CLUSTERS:

Pole cuttings are placed in the ground deep enough to reach the lowest water table of the year and high enough to expose at least two to three buds. Root primordia will develop when good soil-to-stem contact is made and exposed sections of the cutting will sprout stems and leaves. Dormant cuttings can be planted with a digging bar, auger, water-jet, or if the soil is saturated, they may be pushed into the soil. Pole Plantings are planted in the Bank and Overbank Zone and shall be spaced 2–4 feet apart in the row. In multiple row plantings, spacing between rows shall be staggered with respect to those in adjacent rows.

Pole Clusters require four to six inch holes augered into the bank, down to the water table with the use of a hydraulic auger attached to an excavator or tractor. Four willow poles are placed into the hole, backfilled and watered in. A Willow Trench uses pole clusters at 1 foot spacings behind the toe rock that creates a "fence" to filter runoff before it enters the stream and provide dense vegetation to stabilize the eroding bank.
RIFFLE WEIR

Geomorphic riffle weir application for incised channel pool conversion, grade control, floodplain backwatering and fish habitat enhancement.

GENERAL NOTES

1. Feature provides backwater to increase localized water table for hydric vegetation recovery on floodplain.
2. Weir crest invert set at ordinary high water elevation.
3. Constructed of rock, gravels, and large wood providing both fish passage and habitat.
4. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

SOURCES:
USDA NRCS Oregon Standard Drawing No. OR_riffle_weir.dwg, 2006

(Not to Scale)

East Verde River

DETAIL: Riffle Weir

Preliminary Not For Construction

DESIGN BY: A.Haden, S.Yard
DATE: Nov 2011
REVISION DATE:
SHEET NO. 13
GENERAL NOTES

1. Top of footer log shall be one foot below lowest streambed elevation.

2. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

DIMENSIONS

D = __________ (in)

SECTION A VIEW

(Not to scale)

FOOTER LOG

Species____________________

Dia = _____min (in)____max (in)

F = _____min (ft)____max (ft)

ANGULAR ROCKS

Dia = _____min (in)____max (in)

# of rocks per structure__________

SOURCES:
Streambank and Shoreline Protection. EFH-16 (1996 USDA-NRCS)
USDA NRCS Washington Standard Drawing No. BIO-0040, 1999

This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.
TREE COVER

Tree Cover is a technique where trees or large shrubs are felled and anchored at various locations along the streambank to provide needed aquatic habitat. They provide excellent overhead cover and an ideal substrate for aquatic organisms. Under certain conditions, trees can provide excellent benefits with little expense.

Channels must be large enough to accommodate trees without threatening bank erosion and limiting needed channel flow capacity. Suitable trees may not be nearby. Where trees cannot be felled directly into the stream, heavy equipment will be required for placement. Tree covers generally require frequent maintenance; ice is particularly damaging to them.

Minimize disturbance to the stream and adjoining areas by scheduling the work when it will interrupt aquatic plants and animals the least. Greatest benefits probably occur in wide, shallow streams with sand or gravel substrate. Whenever possible, fell trees directly into the stream with tips pointing downstream and with the trunk parallel to or at an angle no more than 20 degrees from the bank. Bank trees can be hinge-felled in shallow streams, but in deeper streams it will be necessary to cut off the tree, place it in the stream, and cable it to the stump, deadman in the bank, or other stable object.

PROFILE VIEW
(Not to scale)

This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

SOURCE:
Stream Corridor Restoration Handbook, USDA.

PLAN VIEW
(Not to scale)

(Not to Scale) | East Verde River
---|---
Natural Channel Design, Inc
206 S. Boden St
Flagstaff, AZ 86001
928-774-2336

DETAIL: Tree Cover

Preliminary Not For Construction

DESIGN BY: A.Haden, S.Yard
DATE Nov 2011
REVISION DATE
SHEET NO. 15
VEGETATED TOE EXTENSION
Provides low water depth and cover

PLAN VIEW
(Not to scale)

SECTION A–A' VIEW
Brush Revetment Extension
(Not to scale)

NOTE: Same layering applys for coir log extension:
Anchored coir log, ballast rock, soil, sedge plantings

DIMENSIONS

\[
\begin{align*}
CW & (ft) \quad L \quad (ft) \\
W & (ft) \quad LN & (ft) \\
(LN < 1/3 \ CW) & \quad LK & (ft)
\end{align*}
\]

BOULDERS
Dia = min(in) max(in)
# of rocks per structure ______

COIR LOGS
Diameter ______(in) Length ______(ft)

GENERAL NOTES
- Used to constrict low water flow which would ordinarily spread over bar in a thinner sheet, unusable by adult fish.
- Captures fine sediments and builds out toe of bank.
- Install in alternating pattern in low slope riffles or runs which are wide and shallow.
- Install brush revetment or coir log, anchored with buried boulders.
- May require additional earth anchor or fence posts to secure brush or coir log.
- Plant with sedges and/or deer grass.
- May need to add some starter material to plant in, or let revetment catch sediment, then plant during next season.
- This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

(Not to Scale)  
East Verde River

DETAIL: Vegetated Toe Extension

PRELIMINARY
Not For Construction

DESIGN BY:
A.Haden, S.Yard

DATE: Nov 2011

REVISION DATE:

DETAIL NO.
16
"W" Rock Weir

**DIMENSIONS**

- CW = _____ (ft)  H = _____ (ft)
- W = _____ (ft)  Hc = _____ (ft)
- Kw = _____ (ft)  $\theta$ = _____ (deg)
- L = _____ (ft)
- Lw = _____ (ft)

**BOULDERS**

- Dia = ___ min(in) ___ max(in)
- # of rocks per structure ______

**GENERAL NOTES**

1. Feature provides backwater to increase localized water table for hydric vegetation recovery on floodplain.
2. Weir crest invert set at ordinary high water elevation.
3. Constructed of rock, gravels, and large wood providing both fish passage and habitat.
4. This standard drawing requires supporting technical documentation prior to use and must be adapted to the specific site.

**PROFILE VIEW**

- Top of bank
- Bankfull
- Upstream pool
- Footer rock
- Structure length (L)

**SOURCES:**

USDA NRCS Oregon Standard Drawing No. OR_wrock_weir.dwg, 2006

**Not to Scale**

**East Verde River**

**DETAIL:**

"W" Rock Weir

**Preliminary**

Not For Construction

**DESIGN BY:**

A.Haden, S.Yard

**DATE**

Nov 2011

**REVISION DATE**

**SHEET NO.**

17
LARGE ROUGHNESS ELEMENTS (LRE)

LRE’s are used to increase the heterogeneity of stream habitat.

GENERAL NOTES

- Large roughness elements provide a natural stream constriction which redistributes substrate size classes creating pockets of greater depth and a more diverse distribution of velocities and substrate size.
- LRE’s also provide vertical structure for fish habitat and are used to create greater extent of pool habitat upstream of the structure by partially damming the stream.

INSTALLATION:

1) Use a large boulder (> D90 of bed particle size) which will not be mobilized by the stream except during extreme flows.
2) Bury boulder approximately one-third of its diameter into the stream substrate. Boulder may need to be placed on suitable sized footer rocks to prevent rolling.
3) When possible, the top of the LRE shall extend above bankfull elevation.
4) LRE’s may be placed along shorelines or midstream. Shoreline placements can take advantage of streamside vegetation for additional habitat cover. Shoreline placements should be placed into bank a distance of 1/3 rock diameter.
5) LRE’s should not be placed adjacent to sensitive, erodible banks.
6) Seed disturbed areas and plant willow cuttings in bank as needed.