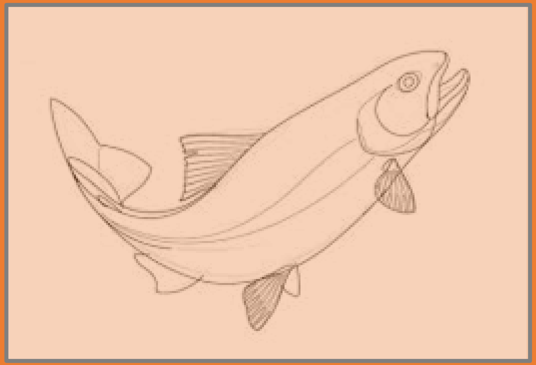
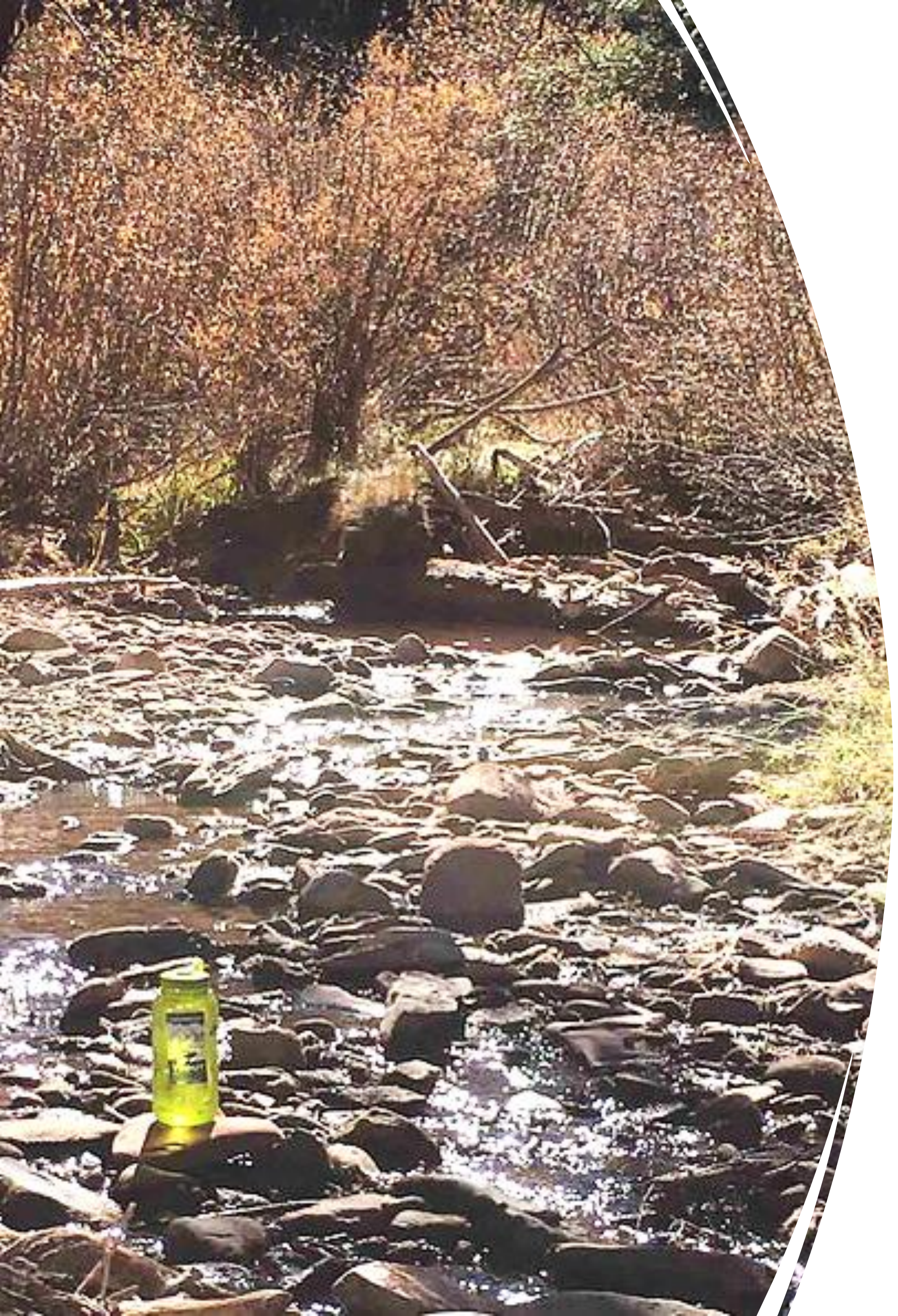


Low Flow Relief

Options and Potential Outcomes for Building Trout Refuge Needed in Southwestern Colorado Mountain Streams

Presentation for Fall Rendezvous, Colorado Trout Unlimited
Glenwood Springs, CO, October 21-23, 2022

Raymond Rose & Duncan Rose



Introduction

- Low streamflow is a problem
- In upper Dolores River basin streams,
- Occurring <u>more frequently</u>
- And with <u>less water</u>
- Due to climate change.
- (Low flow at Ryman, October 2020.)

Background

- 2018, second lowest flows in 71 years.
- 2020, some small streams dewatered to dryness.
- Low flows jeopardize trout populations.
- (Dry streambed at Taylor, October 2020.)

Question

- Snowmelt brings lots of water.
- Question: What about holding some
- And making it accessible
- As refuge for trout during low flows?
- (High flow at Wildcat, May 2022.)

Options

1. Plunge pools
2. Backup pools
3. Pond

Plunge pools option

- Refuge volume is created from
- Increased water depth
- From scouring at high flows,
- Downstream of a structure
- Such as a fallen or placed log.
- (Scouring potential at Wildcat, May 2022.)

Backup pools option

- Refuge volume results from
- Increased water <u>height</u>,
- But *not* width,
- <u>Upstream</u> of a dam structure.
- (Hint of a backup pool at Ryman, May 2021.)

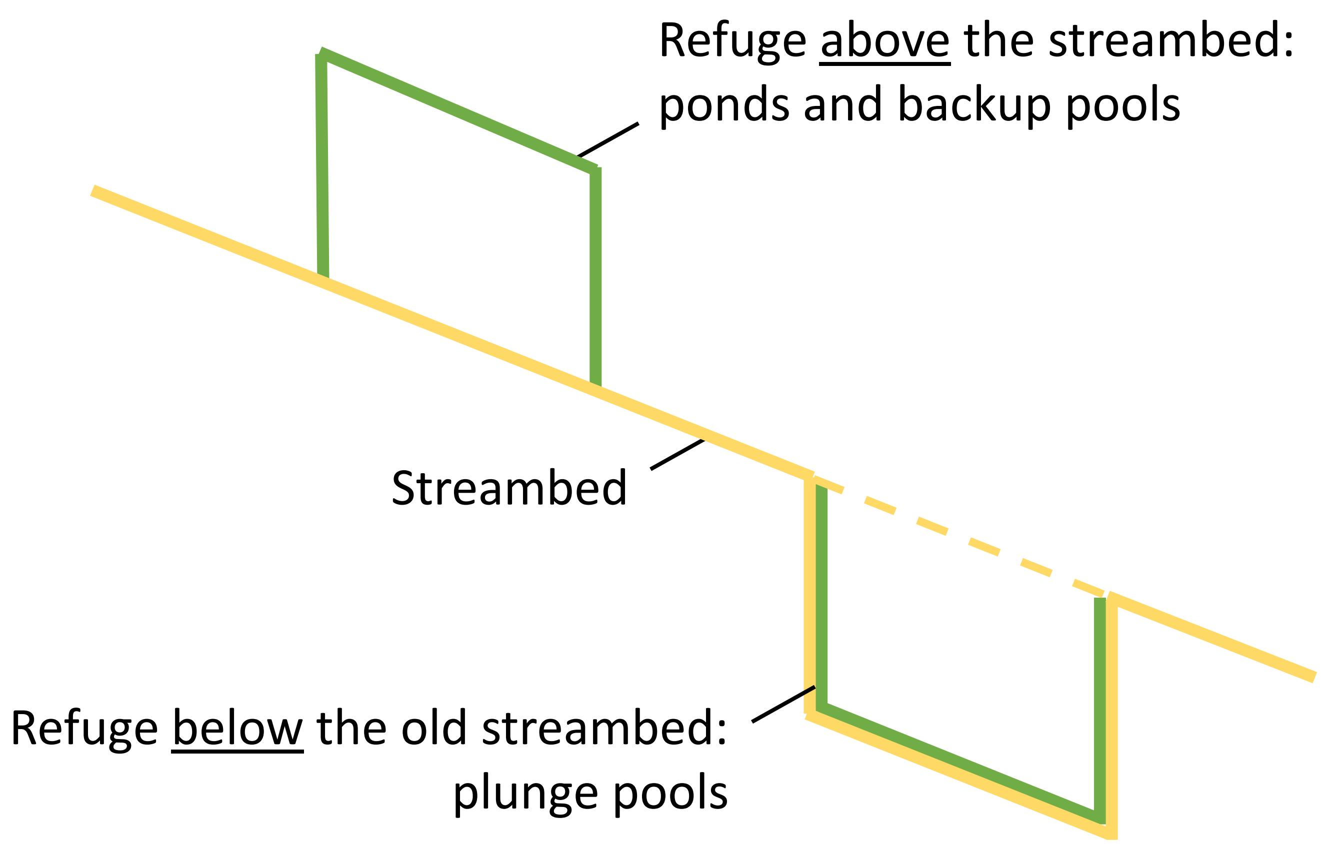
Pond option

- Refuge volume is built by
- Increasing water height *and* width
- Upstream of a dam structure.
- (Beaver dam at Taylor, June 2021.)

Pond washout

- Same location,
- But washed out now
- From high flows,
- Showing past silt accumulation
- That reduced refuge volume.
- (Washout at Taylor, September 2022.)

Difference in refuge placement



Pond size

- Estimated pond volume, <u>1575</u> cf.
- From an estimated:
  30 ft wide, 35 ft long, and 1.5 ft deep.
- (May 2021 flow at Ryman.)

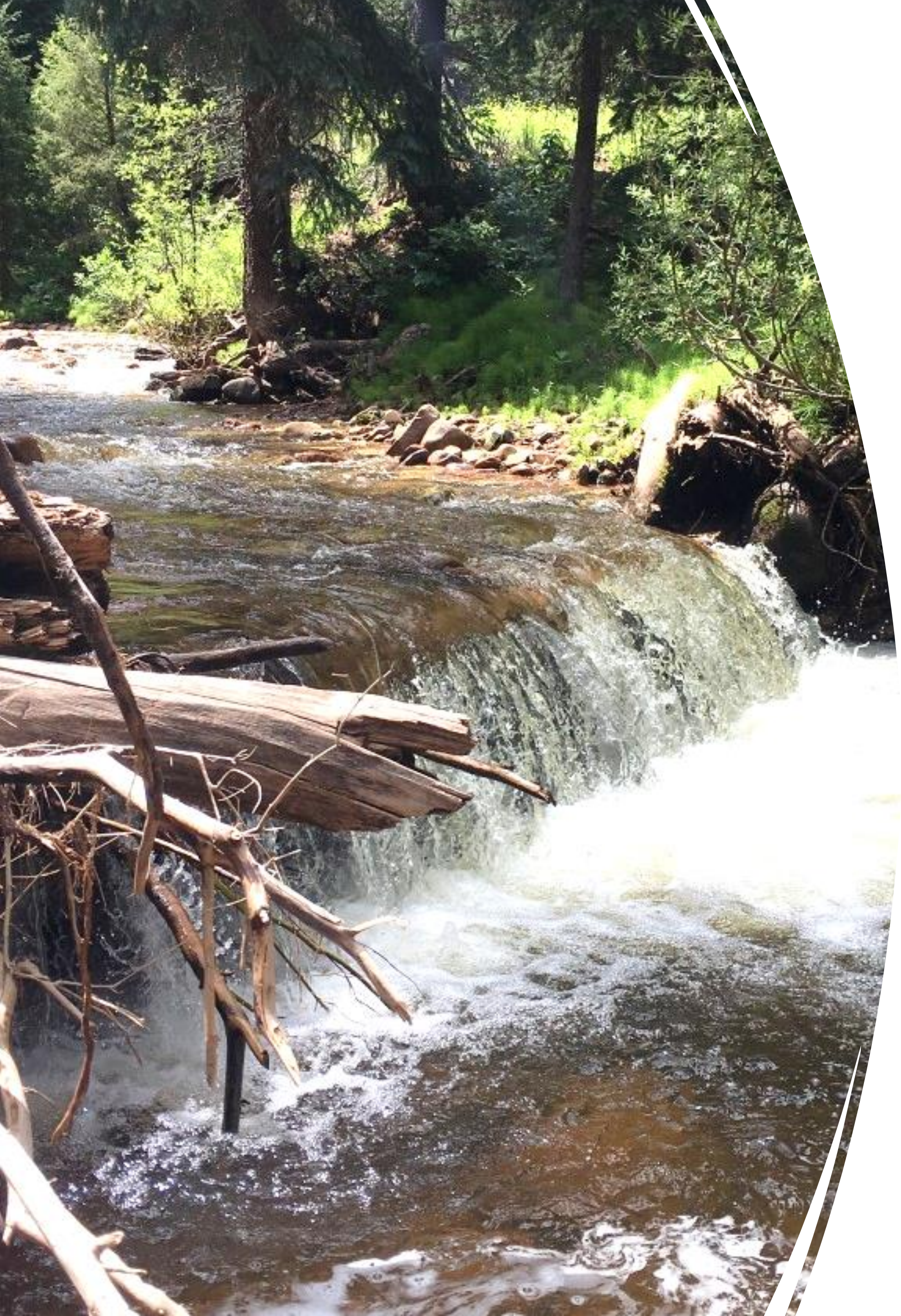
Plunge pool size

- Plunge pool volume, <u>96</u> cf,
- From measurements:

  6 ft wide, 8 ft long, and 2 ft deep.
- Range of plunge pool sizes:
  - <u>5-7</u> ft wide
  - <u>5-10</u> ft long
  - <u>1-4</u> ft deep
- (May 2021 flow at Ryman.)

Plunge pool detail

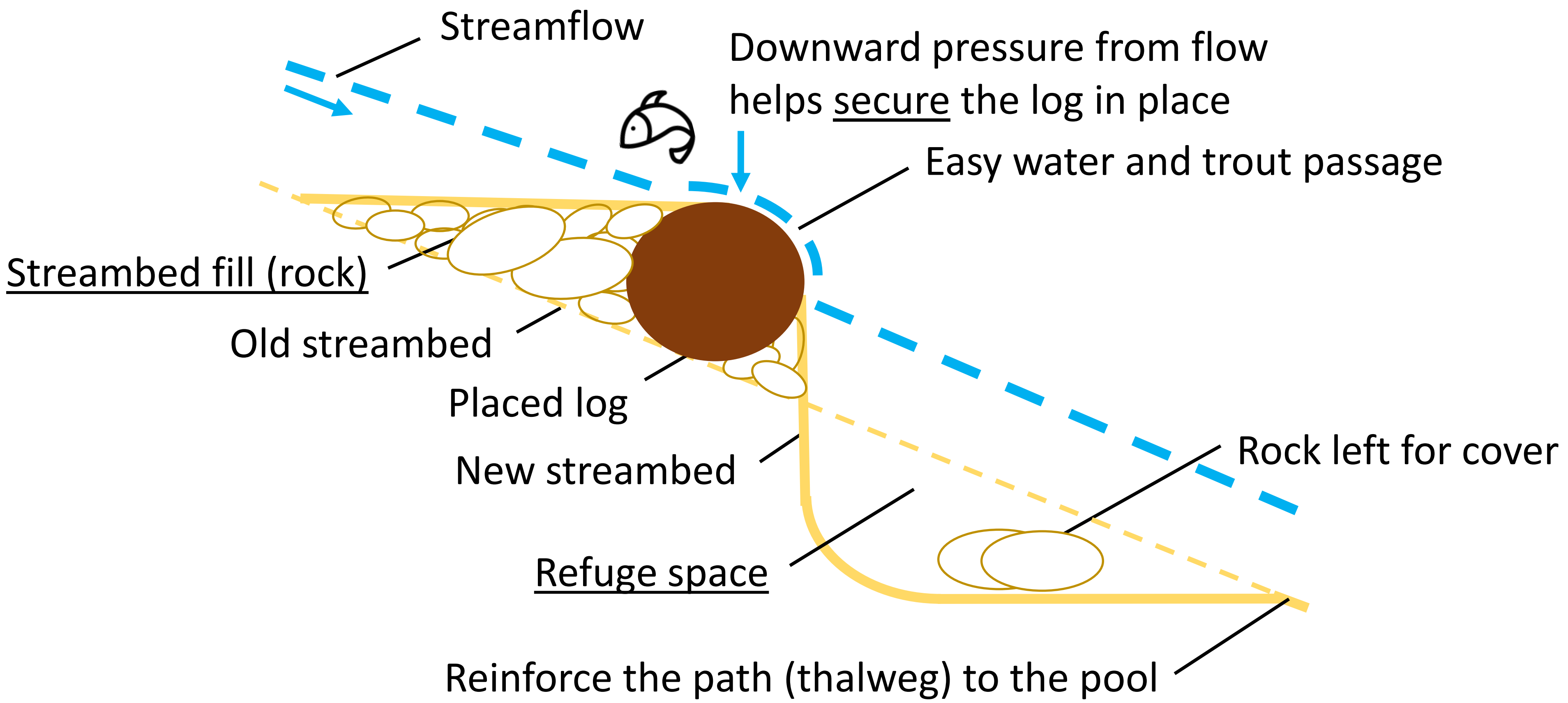
- Streambed fill (rock)
- Has <u>collected behind</u> the log
- And directs flow over it,



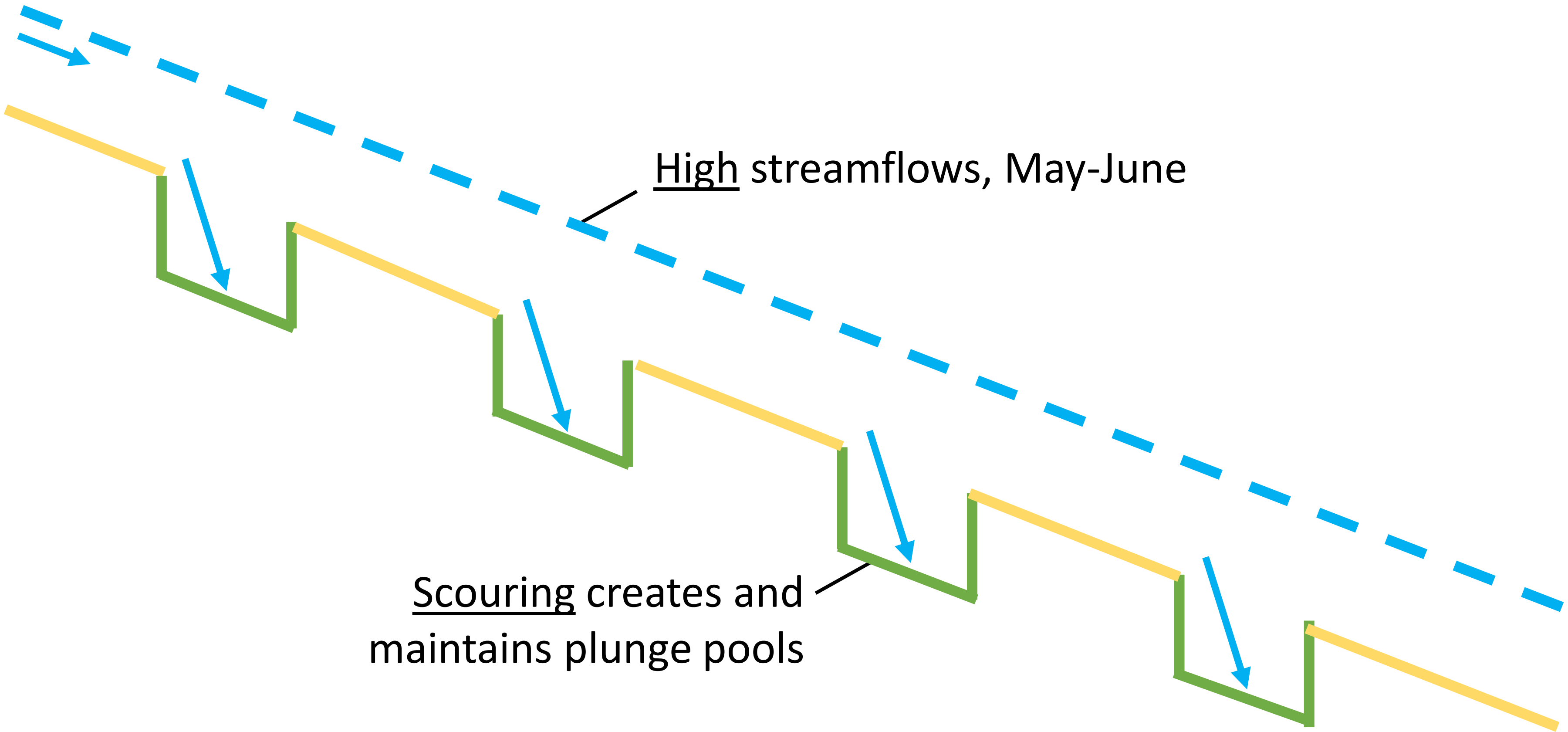
Plunge pool detail, ctd.

- Which helps secure the log
- With downward flow pressure,
- Instead of broadsiding and dislodging it.
- Rock fill behind the log also prevents the development of scouring under it.
- (July 2019 flow at Roaring Fork.)

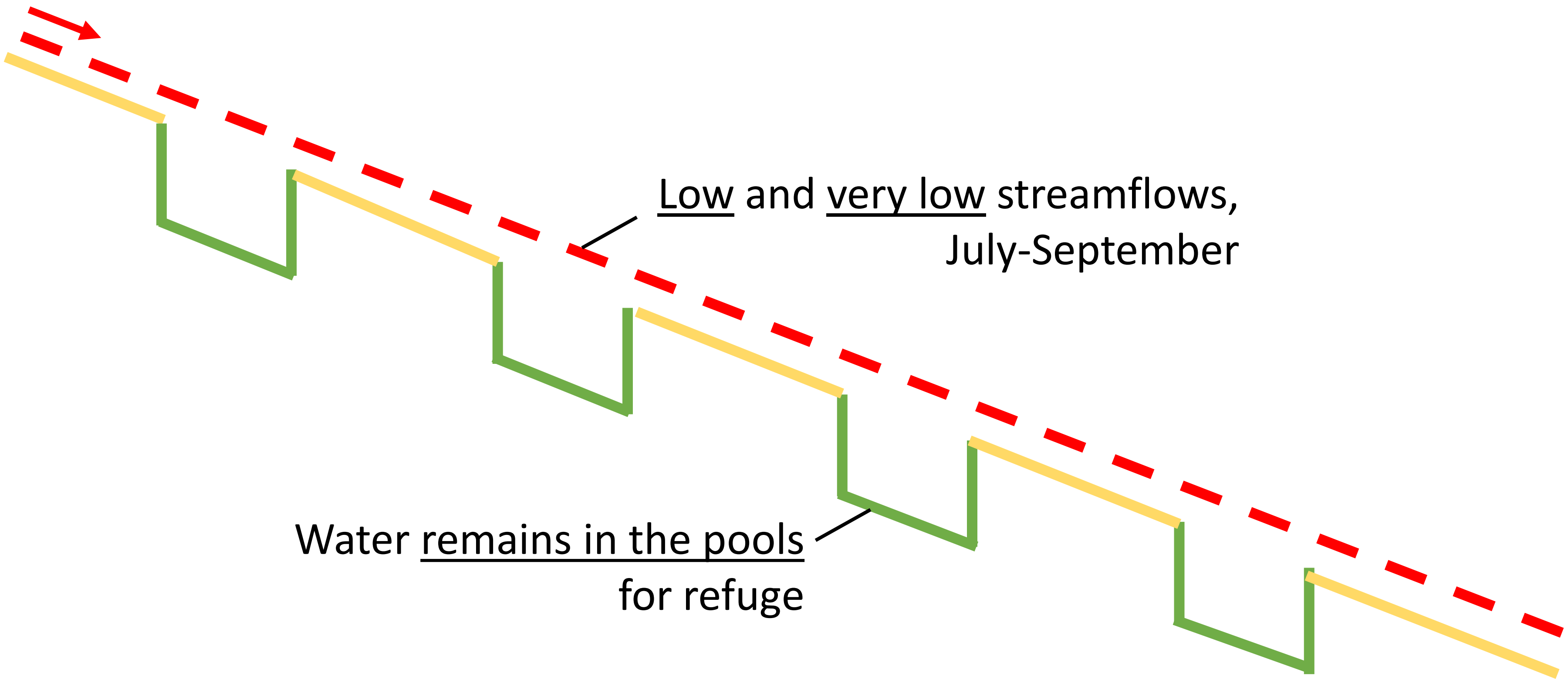
Plunge pool configuration

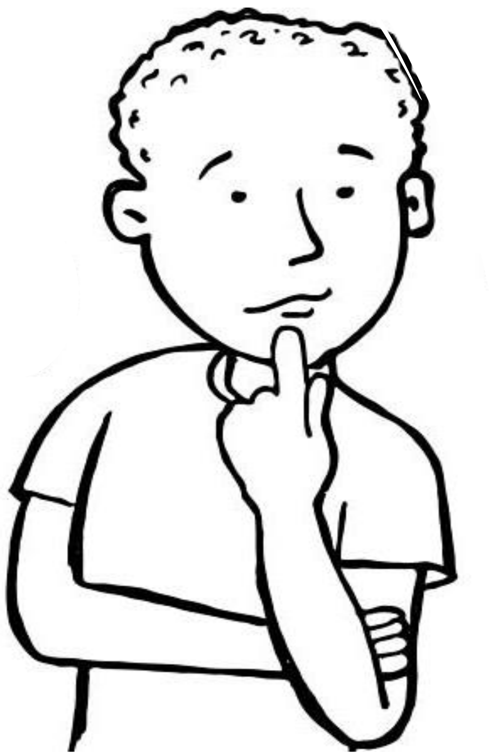


Plunge pools created and maintained in high flows



Plunge pools as refuge in <u>low flows</u>





Noting

- Plunge pools are topped off at high flows
- If they have lost refuge volume,
- Then draw no more stream water.
- A perpendicular log maximizes pool width.
- Reinforce the path (thalweg) to the pool.
- Pools and ponds may augment baseflow.
- Pools don’t add to evaporation; ponds do.

Testing

- “Testing” conceptually an idea of refuge
- Where it matters most,
- At small streams,
- Which have the least water to lose
- Before problems develop for trout.
- Half of upper Dolores basin streams are small,
- Less than 6 mi long and 6 sq mi drainage area.

Testing, cont.

- Using: <u>Regular</u>, <u>low</u>, and <u>very low</u> flow values from the small streams Wildcat and Ryman,
- <u>Sizes</u> for a <u>pond</u> and <u>plunge pools</u> from observations at those streams,
- Smaller dimensions from the ranges to avoid overstatement in representing them,
- And a reasonable size for <u>backup pools</u> since no true ones were found.

Construction

- Materials: trees, logs, rocks, brush, mud.
- Tools: saws, winches, pry bars, shovels, ropes.
- Level of effort: 40 hrs, 4-person crew per option, estimated.
- About a week or so to complete an option.
- (So far, conceptual; no construction yet.)

Example

- A log across the stream
- That could be cut and dropped
- Onto the streambed, followed by
- Transfer of streambed material
- From downstream to behind the log,
- Initiating the scouring of a plunge pool.
- (June 2022 flow at Wildcat.)

Evaluation

- Volume of refuge.
- Resilience of structure.
- Use of space by trout.
- (Electro-fishing in a naturally occuring plunge pool at Wildcat, May 2022.)

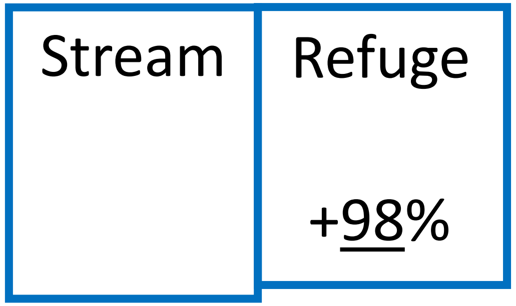
Working with options

- <u>Plunge pools</u> can be widely distributed,
- But are small individually.
- A <u>pond</u> is 30 times larger.
- Is more difficult to build, however.
- Will leak and accumulate silt over time,
- Reducing its volume.
- (Silt behind dam, Ryman, September 2022.)

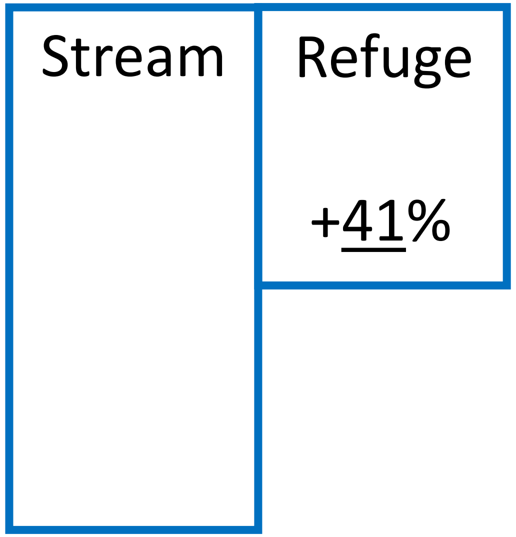
Working with options, cont.

- Even reduced by 50%,
- A pond is 15 times larger than a plunge pool.
- And possibly has a greater food supply.
- Could be a <u>last resort</u> for trout in low flows.
- <u>Both</u> plunge pools and a pond may be best.
- (Pond intact, Taylor, June 2021.)

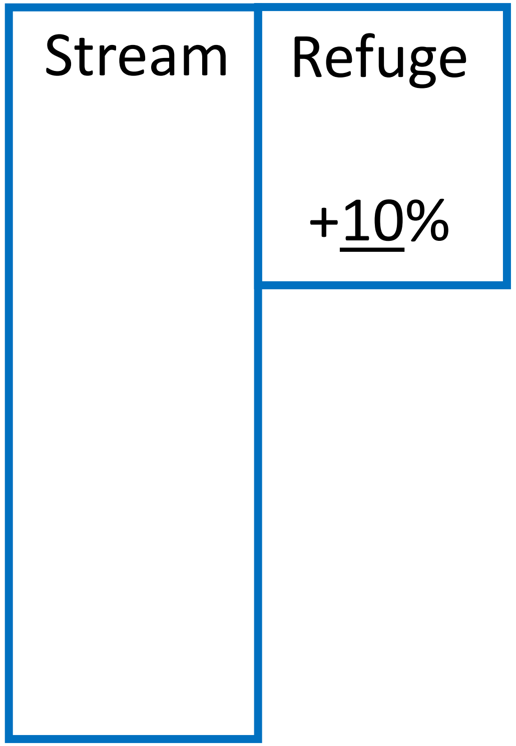
Results: Percent volume increase, Wildcat



Increased volume
at very low flow,
7D10Y, *StreamStats*



Increased volume
at low flow,
25% of regular



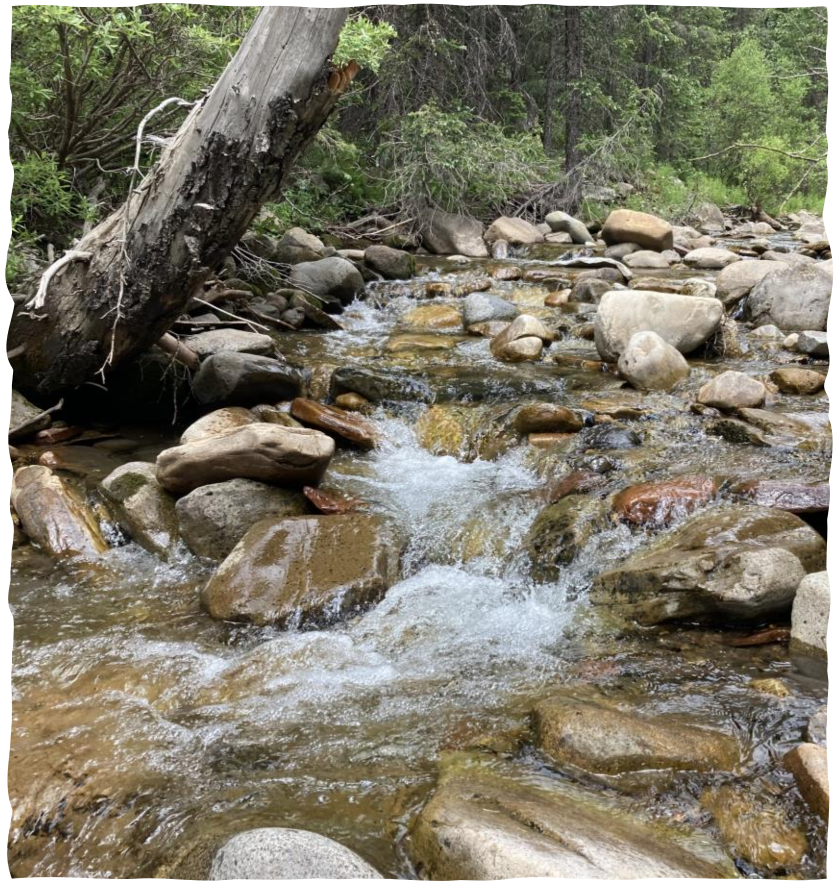
Increased volume
at regular flow,
StreamStats

(Refuge volume, 2700 cf, lower 2 mi, August)

Results: Equivalent volume comparison, main stem

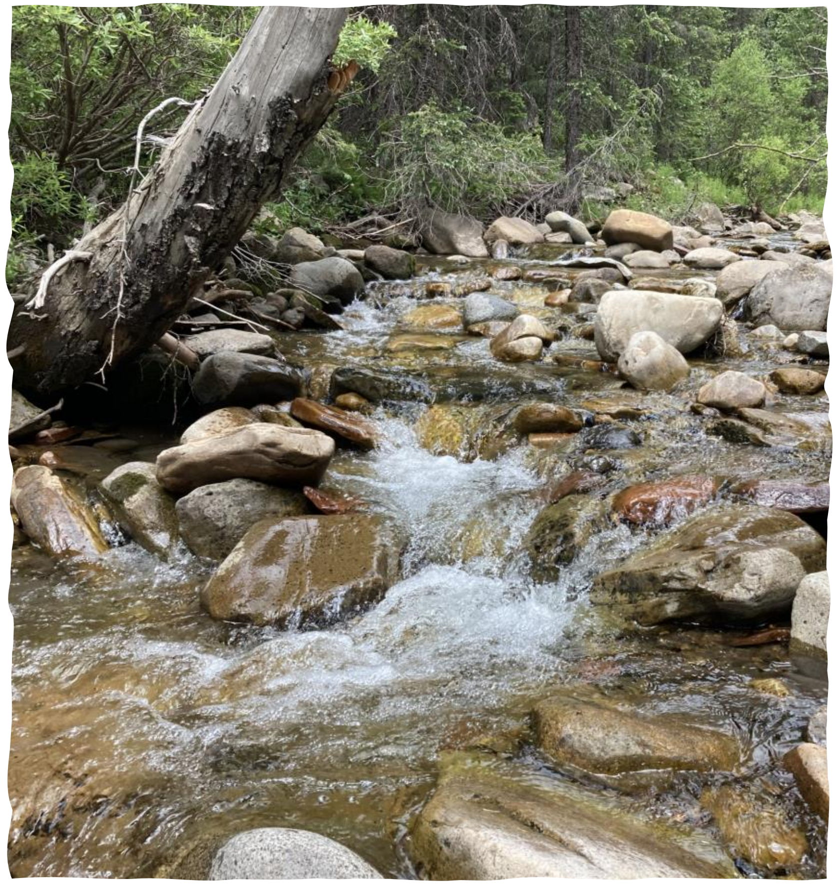
- Number of refuge volumes, 2700 cf each,
- That are equivalent to 0.1%
- Of June-September main stem flow
- Where it enters McPhee reservoir:
  - 2159 at regular flow, *StreamStats*
  - 539 at low flow, 25% of regular
  - 94 at very low flow, 7D10Y
- (Low flow, main stem at Rico, October 2020.)

Summary and conclusions



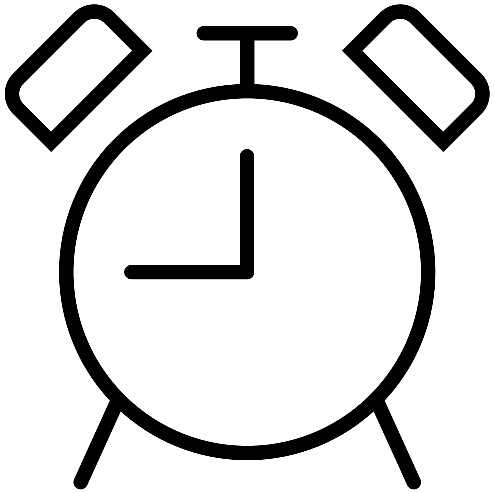
- Plunge pools can be the *distributed*, *no-maintenance*, and *resilient* component
- Of a twin installation of plunge pools and a pond.
- Plunge pool structures enable easy passage of trout and low flows.
- Backup pools offer *no improvement,*
- Being less distributed than plunge pools,
- And, like ponds, they leak and accumulate silt.

Summary and conclusions, cont.



- Ponds need periodic maintenance.
- Evaporation loss at a pond is unfortunate,
- But *not significant* to downstream main stem flow.
- Plunge pools and ponds may augment baseflow.
- Installed together, <u>plunge pools</u> and a <u>pond</u>
- *Can create needed*, <u>consequential refuge</u> for trout.

Currently



- No low flow relief actions taken yet.
- Current candidate stream is Wildcat, which
- Hosts historic genetic strain of cutthroat trout.
- Collaboration with U.S. Forest Service is ongoing.
- Pond and some scouring structures are being considered.
- Local TU chapter is assisting with funding,
- Initially for an archeological study, and
- Later for installation work crews.

Thank you

The appendix pages that follow have additional details about low flow relief and show calculations.

This can be downloaded at DoloresStudy.org.

Appendix: Looking forward

- Distinctive, perhaps novel, is the opportunity
- To manage down low streamflow problems,
- Preventing damage to trout populations
- By making use of abundant flows,
- So refuge is available for trout at low flows.
- Can be built readily, efficiently, and soon,
- With materials collected from streamside
- And using simple, portable tools.

Plunge pools option

- Advantages
  - Simplest to build; most distributed; lowest maintenance.
  - Will not increase evaporation loss; no dam; least likely to wash out.
  - Readily enables water and trout passage.
  - May augment baseflow.
- Disadvantages
  - Smallest individual volume.
  - Numerous installations.

Pond option

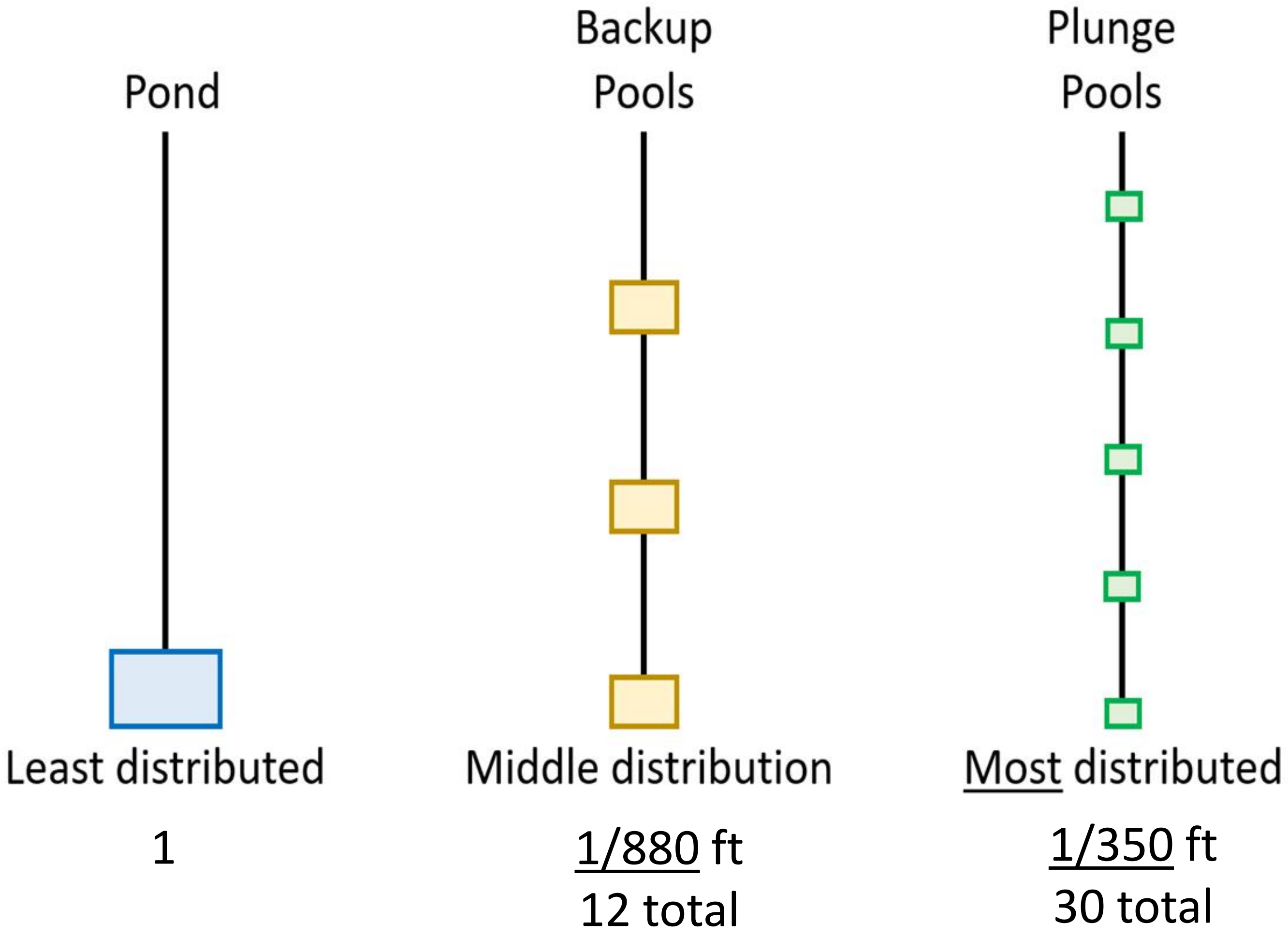
- Advantages
  - Largest individual refuge volume.
  - May augment baseflow.
- Disadvantages
  - Will increase evaporation loss.
  - Least distributed.
  - Will leak; largest dam, most maintenance.
  - Will accumulate silt, which reduces refuge volume.
  - Subject to washout.

Backup pools option

- Advantages
  - Will not increase evaporation loss.
  - May augment baseflow.
- Disadvantages
  - Will leak; lots of installation locations needing maintenance.
  - Will accumulate streambed material and silt, reducing refuge volume.
  - Subject to washout.

Options Distribution

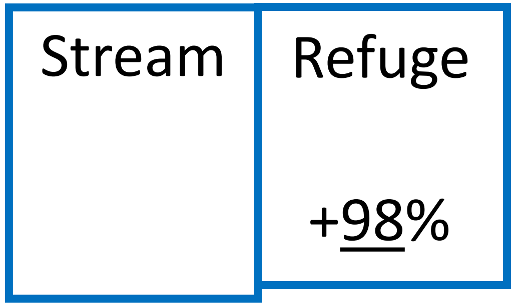
Placed in a stream’s lower 2 miles



Conceptual representative sizes

- For "testing" the small-stream refuge idea:
- Pond is 30 ft wide, 30 ft long, and 1.5 ft deep, volume 1350 cf,
- Backup pool is 5 ft wide, 15 ft long, and 1.5 ft deep, volume 112.5 cf (12 = 1350 cf),
- Plunge pool is 5 ft wide, 6 ft long, and 1.5 ft deep, volume 45 cf (30 = 1350 cf).
- "Testing" is comparison of conceptual refuge with small stream and main stem volumes.

Results: Percent volume increase, Wildcat



Increased volume
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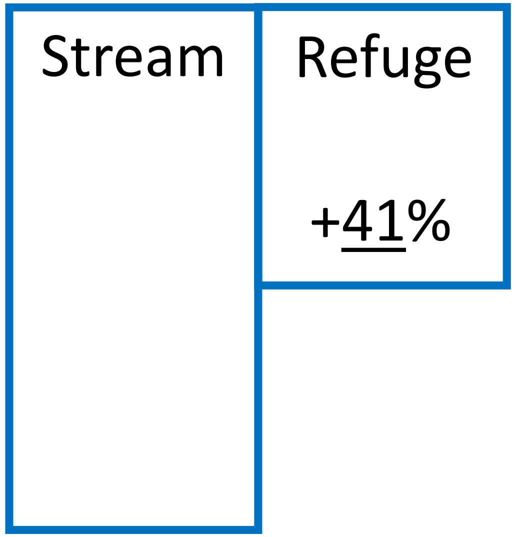
7D10Y, *StreamStats*



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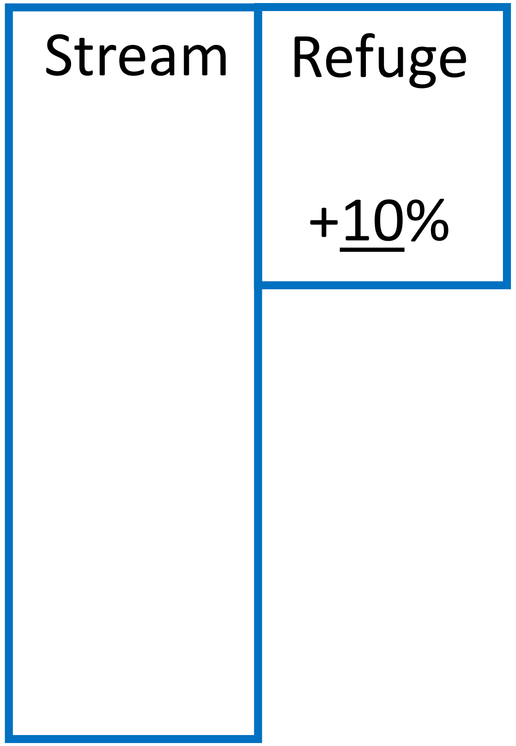

Increased volume
at regular flow,
StreamStats

(Refuge volume, 2700 cf, lower 2 mi, August)

Calculations, percent increase, Wildcat

- August flows; lower 2 mi of stream volume.
- Regular and 7D10Y flows from *StreamStats.*
- Stream volume, without refuge:
  - 26,083 cf, regular flow, 2.47 cfs, mean
  - 6521 cf, low flow, 25% of regular flow
  - 2809 cf, very low flow, 0.266 cfs, 7D10Y
- Refuge volume:
  - 1350 cf, 30 plunge pools
  - 1350 cf, 1 pond
  - 2700 cf, total, plunge pools and pond
- Percent increase in stream volume with refuge:
  - 10% at regular flow
  - 41% at low flow
  - 98% very low flow

Calculations, stream volume, Wildcat

- August flows; lower 2-mi stream section.
- Regular and 7D10Y flows from *StreamStats.*
- Volume, cf = cross-section area, sf x section length, ft.
- Cross-section area, sf = mean flow, cfs/1 ft.
- Mean flow, cfs = (Outfall, cfs + 2-mi, cfs)/2.
- For regular, low, and very low flows.
- Stream (2-mi section) volume:
  - <u>26,083</u> cf, regular flow, 2.47 cfs, mean
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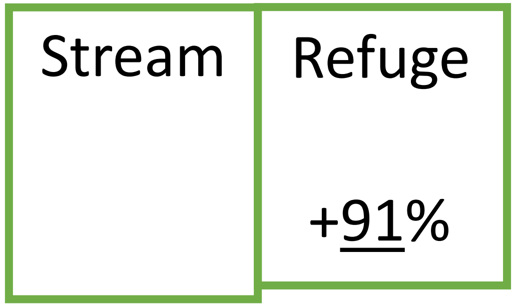
Results: Percent volume increase, Ryman



Increased volume
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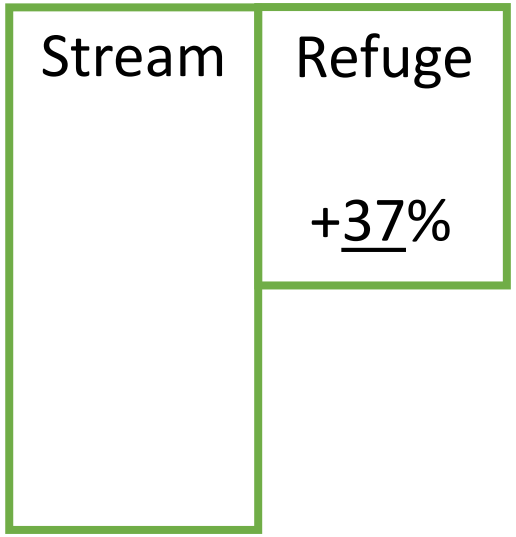
7D10Y, *StreamStats*



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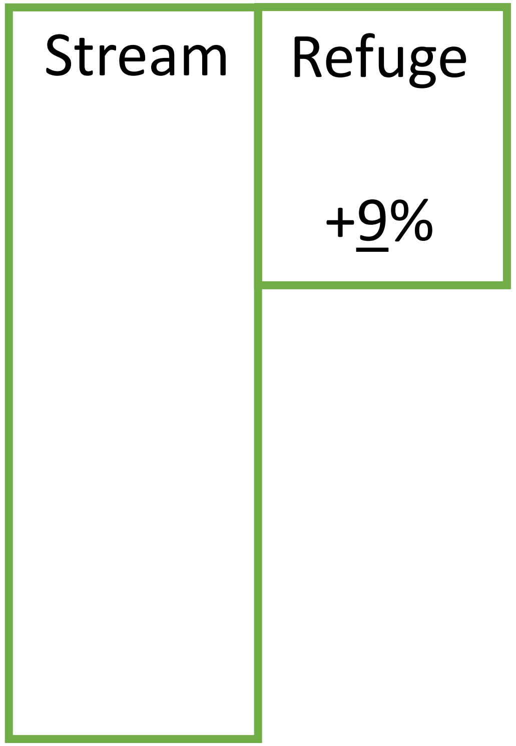

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Results: <u>Percent</u> volume comparison, main stem

- Refuge volume, 2700 cf, as a <u>percent</u>
- Of June-September <u>main stem flow</u>
- Where it enters McPhee reservoir:
  - <u>0.000046</u>% at regular flow, *StreamStats*
  - <u>0.00019</u>% at low flow, 25% of regular
  - <u>0.0011</u>% at very low flow, 7D10Y
- (Low flow, main stem at Rico, October 2020.)

Calculations, <u>percent</u> comparison, main stem

- June-September flows where the main stem enters McPhee.
- Regular flows from *StreamStats.*
- Main stem flow:
  - <u>553</u> cfs, regular flow, mean
  - <u>138</u> cfs, low flow, 25% of regular flow
  - <u>24.2</u> cfs, very low flow, 7D10Y
- Main stem flow volume, cf = flow, cfs x time, s
- Refuge volume:
  - 1350 cf, 30 plunge pools
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- <u>Percent</u>, refuge to main stem volume:
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Results: Equivalent volume comparison, main stem

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Calculations, percent and equivalent comparisons

Tool for comparing refuge and river volumes

Item	Calculations	Description
		Refuge
1	**30**	Refuge *width* in ft. Refuge width, length, and depth are used to calculate a hypothetical refuge volume for comparing with a river volume.
2	**30**	Refuge *length* in ft.
3	**1.5**	Refuge *depth* in ft.
4	1,350	Refuge *volume* in cubic ft (cf).
5	**2**	*Number* of refuge volumes. This is used to calculate total refuge volume.
6	2,700	*Total* refuge volume in cf.
		River
7	**122**	*Period of time* in days. This is used to calculate the river volume.
8	**553**	*River flow* in cfs.The flow at a river location for the period of time.
9	10,540,800	*Conversion factor* in seconds for changing a value expressed as a rate (cfs) to one expressed as a volume (cf), that is, the volume during the period of time.
		(60 sec/min x 60 min/hr x 24 hr/day x period of time, days)
10	5,829,062,400	River *volume* in cf. This is the volume at a river location for the period of time.
		(river flow, cfs x conversion factor, which is river flow, cfs x 60 sec/min x 60 min/hr x 24 hr/day x period of time, days)
		Comparison
11	0.00000046	*Fraction* of the total refuge volume to the river volume at a river location for the period of time.
		(refuge volume, cf/river volume, cf)
12	**0.000046**	Percent of the total refuge volume to the river volume at a river location for the period of time.
		(100 x total refuge volume, cf/river volume, cf)
14	**2159**	*Number* of total refuge volumes equivalent to *0.1 percent* of the river volume at a river location for the period of time.
		(0.001 x river volume, cf/total refuge volume, cf)