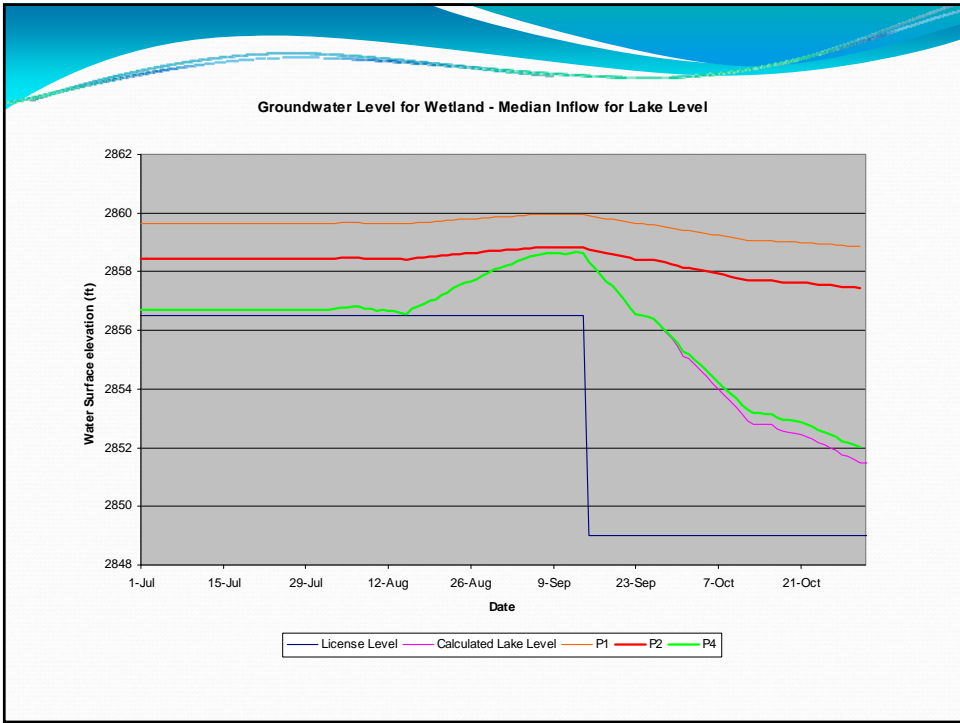
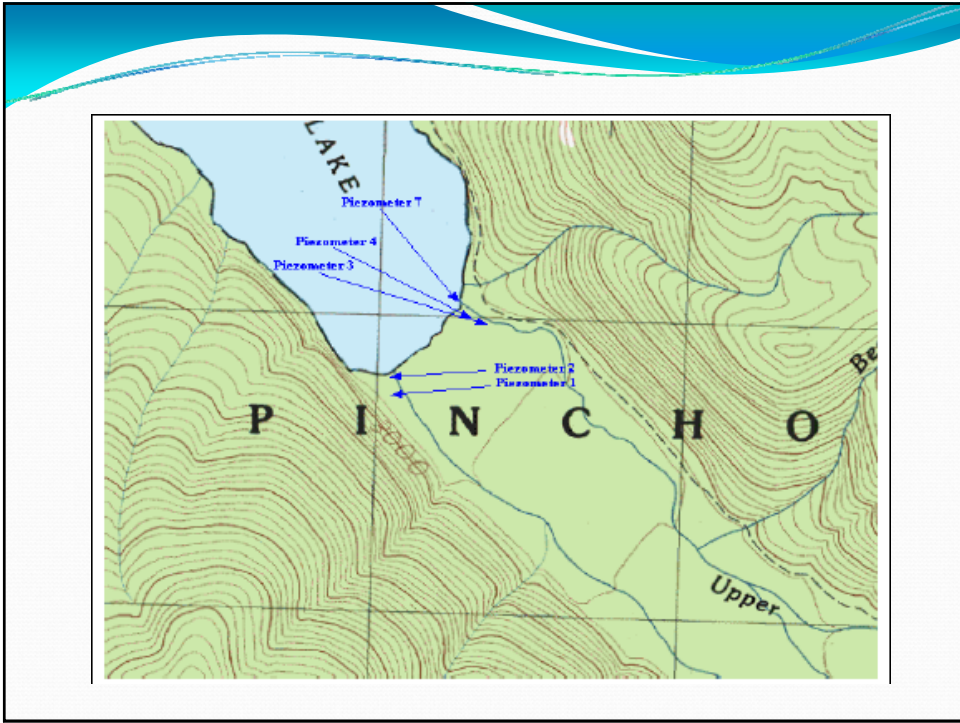


Winter Drawdown – Issues of Concern

- Wetland Connectivity
- Amphibians
- Fisheries

Winter Drawdown – Wetland Connectivity

- Wetland complex near Osprey Creek is not responsive to lake level
- Wetland at upper end of lake: Groundwater level in portion of wetland nearest the shoreline responds to lake level during dry season (July 1 – Oct 31)
- Wetlands not responsive to lake level Nov – June
- Drawdown after annual maintenance outage (Sept 16 – Oct 31) more gradual
- Winter lake drawdowns typically only to 2853-2854 ft range but need to keep operational ability to go down to 2849 ft

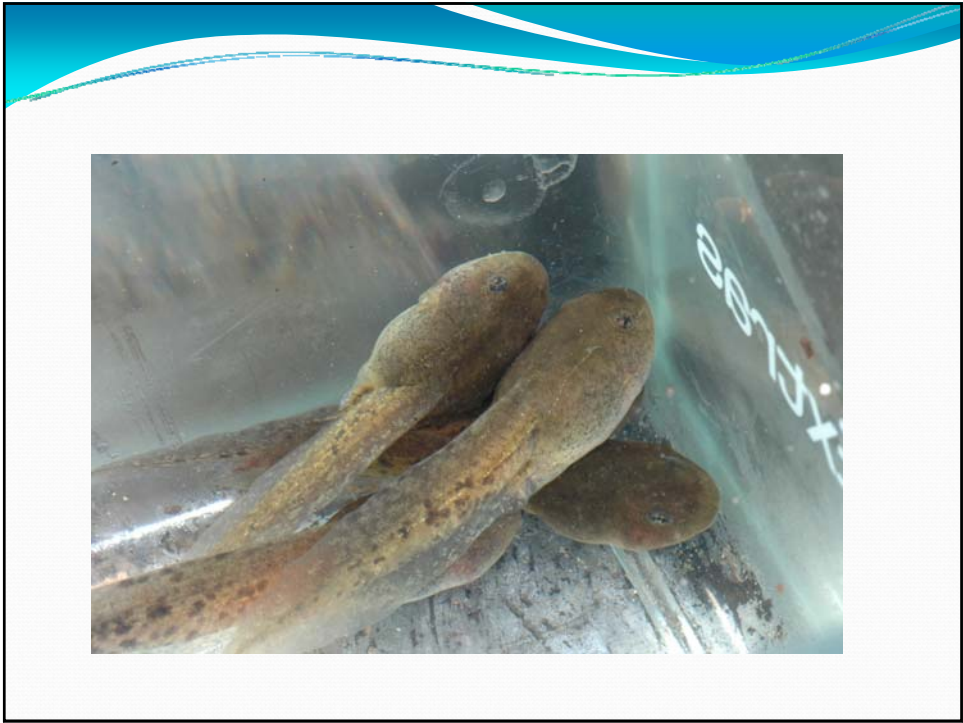


Summary of Wetland Effects

- Wetland groundwater response to drawdown following annual outage is about 1ft below summer level for P1 and P2 (near Muller Cr)
 - Soil remains saturated in rooting zone
 - Typical drawdown less than 2849 ft
 - Vegetation going dormant in the fall
- At P4, groundwater closely tracks lake level
 - By July 31, groundwater level is already below rooting zone
- Groundwater level slightly higher during outage due to higher lake level

Winter Drawdown – Amphibians

- Amphibian habitats on the perimeter of Packwood Lake occur only at Osprey Creek and at the upper end of the Lake.
- Three species occur: Pacific treefrog, Cascades frog, and northwestern salamander; each species breeds in ~ early May.
- Pacific treefrog and Cascades frog larvae complete metamorphosis ~ late July - August, and would be unaffected by lake drawdown after metamorphosis (post-metamorphic stages can move freely over land to select habitats).
- The life history cycle of the northwestern salamander is distinctly different...

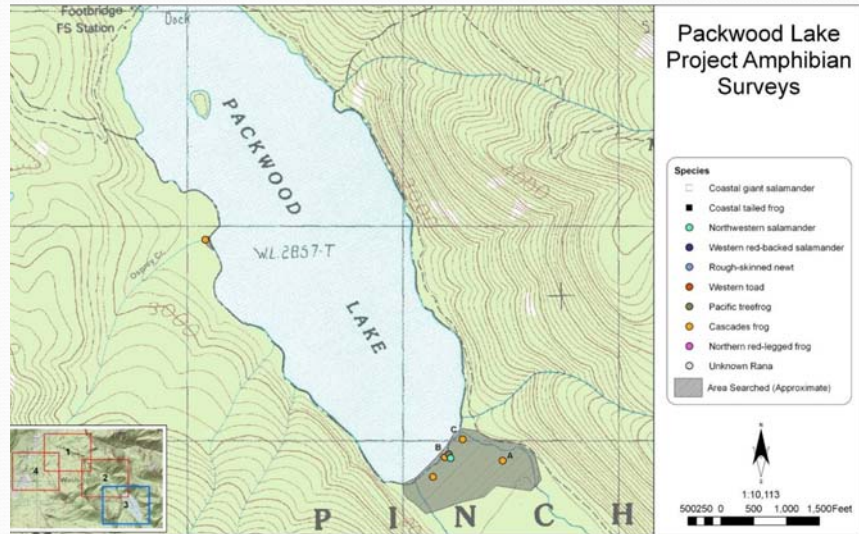


Northwestern salamander life history

- Terrestrial adults are forest-dwelling and migrate to breeding sites in late winter or early spring (depending on elevation).
- Egg masses (usually containing 50-200 eggs each) in Packwood Lake area probably laid ~ early May, attached to submerged vegetation or twigs; embryos develop slowly; and eggs hatch after ~ 1.5 months.
- Larvae grow slowly; each larval cohort over-winters before metamorphosing in second summer (~ July).
- Thus, larvae require permanently flooded wetland conditions to survive to metamorphosis.
- Species may occur at sites with fish, if adequate hiding areas (submerged logs, debris, or loose sediments) are available; and at some locations mature as a gilled, aquatic (paedomorphic) form.



Wetlands with amphibian detections near Packwood Lake
(lake at 2,857 + 0.5 ft elevation during July 2006 survey)



Location near Muller Creek: Shallow water,
Cascades frog adults only (not a breeding site)



Site A: Tributary of Upper Lake Creek. Cascades frog larvae found in pool in forested wetland on July 18, 2006. Area unaffected by drawdown.



Site C: Small, shallow pool at lake edge, Cascades frog larvae found in 2006. Area dewatered during winter drawdown, but larvae already metamorphosed.



Site B: Connected to Lake, with some areas 3 – 4 ft deep on July 18, 2006. This is the only site where northwestern salamander larvae were found.



Site B: Shallow areas are 1-2 ft deep, with emergent vegetation.



Site B: Continuous with Lake, deepest water is in area with accumulated logs. Northwestern salamander larvae may be able to move into deeper waters of lake at drawdown.



Site B is associated with a long channel that extends back into forested wetland.



Summary of Amphibian Issues

- Larvae of one species (northwestern salamander) will be present during drawdown regardless of timing. Pacific treefrog and Cascades frog metamorphose late July-August and any stragglers should survive a gradual drawdown beginning September 15 (pond drying is a trigger to metamorphosis).
- The only site suitable for northwestern salamander is Site B.
- Because Site B is connected to the lake, drawdown expected to cause the same change in water level, with dewatering when lake is at about 2,853 ft.
- However, it is possible that parts of Site B will retain water if hydrology is affected by wetland groundwater (wetland groundwater response to gradual fall drawdown after outage is about 1 ft or less for most of wetland).

Fisheries Issues

- Juvenile utilization of shoreline habitat
 - In general, juvenile trout utilize shallow water in littoral zones within 2 to 5 m of shore (Wurtsbaugh et al., 1975)
 - Juveniles are more abundant in complex inshore habitats than simple habitats
 - Simple habitat: sand or gravel bottom without cover
 - Complex habitat: large boulders, undercut banks, submerged logs, aquatic vegetation present with cover
 - Cover is preferred (Tabor and Wurtsbaugh, 1991)
 - Submerged logs
 - Aquatic vegetation
 - Overhanging branches/logs
 - In general, adults do not utilize shoreline habitats (Post et al., 1998)

Fisheries Issues

- Juvenile progression away from shore
 - Littoral habitat → Benthic habitat → Pelagic habitat
 - Influenced by the presence of predators (birds, otters, other fish)
 - Without predators, juveniles will venture away from shore sooner (Landry et al., 1999)
 - Timing of progression away from shore
 - A study in Lake Washington suggests that rainbow trout don't move away from shore until April or early May (Beauchamp, 1990)
 - By September, their diet is mostly from benthic sources (Wurtsbaugh, et al., 1975)
 - Macroinvertebrate larvae, small crayfish, etc.

Fisheries Issues

- Juvenile Diet
 - Mainly Zooplankton
 - Daphnia spp. are preferred (Irvine and Northcote, 1982; Tabor and Wurtsbaugh, 1991)
 - The diet of rainbow smaller than 250 mm in Lake Washington is made up mostly of Daphnia spp. (Beauchamp, 1990)
 - Consumption of Daphnia spp. is higher during the day than at night
 - Seasonal Changes
 - As the size of juveniles increases, so does the size of their prey
 - Larger invertebrates and benthic insects become focus of diet
 - Benthic feeding increases in the summer (Rowe, 1984)
 - Daphnia density in Packwood Lake decreases drastically in August (EES, 2005)

Fisheries Issues

- Cannibalism
 - No firm evidence in literature to support or reject hypothesis of cannibalism in rainbow trout
 - Rainbow will eat other fish...
 - Percentage of diet made up by fish increases with size
 - Piscivory usually does not occur until fish are at least 150 mm long
 - Piscivory makes up much larger percentage of diet in larger fish (350 mm+)

Winter Drawdown – Littoral Habitat

Table 4.1 – Surface Area for Packwood Lake and Acreage Affected by Drawdown
Acreages per 1-foot contour between El. 2859 and 2849.

Water Surface Elevation (ft)	Surface Area (acres)	Change in Area (acres)
2859.0	460	0
2858.0	456	4
2857.0	452	4
2856.0	448	4
2855.0	445	3
2854.0	441	4
2853.0	437	4
2852.0	433	4
2851.0	430	3
2850.0	426	4
2849.0	422	4



Fisheries Issues - Conclusions

- Unique situation in Packwood Lake
 - Rainbow trout are the only fish documented in Packwood Lake
 - Likely timeline
 - From outmigration (July-September) fry utilize littoral habitats until they reach a certain size
 - Due to the presence of snow and ice in the littoral areas, rainbow trout juvenile *may* move offshore during the winter months
 - Once the juveniles are of sufficient size (May/June) they migrate away from littoral habitats (visual observations have confirmed wide distribution of fish throughout the lake during this time)
 - During the summer months (July-August) rainbow utilize benthic habitats for feeding
 - Low zooplankton densities during this time
 - Benthic zone is a good food source during this time
 - Cooler water temperatures