Status of the Yakima River Decision Support System, June 2007

By Ken D. Bovee
U.S. Geological Survey
and
Jeff Thomas
U.S. Fish and Wildlife Service

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Purposes of the YRDSS

• To quantify changes to selected decision variables related to changes in water management in the upper Yakima basin.

• To summarize and display the changes in a concise and easily understood format.

Organization of the YRDSS

- **Principal driver is Bureau of Reclamation systems operation model, RiverWare.**

- **Output from RiverWare used as input to linked models for other components, or exported directly to YRDSS.**

- **YRDSS consists of multiple, linked Excel workbooks, automated by Visual Basic macros.**

Decision Variables in the YRDSS

- **Habitat responses for selected target (fish) species.**
- **Temperature changes during important biological time windows.**
- **Water availability and proration rates.**
- **Reservoir storage and passage for bull trout and smolts from selected reservoirs.**
- **Overbank flows and potential flood damages.**
- **Sediment transport.**

Time series analysis

- **All decision variables quantified over a 22 year period of record: WY 1982 – WY 2003.**

- **Results displayed for each year and summarized for period of record.**

- **Some variables (e.g., proration rates) displayed monthly.**

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Information Flow for YRDSS Decision Variables
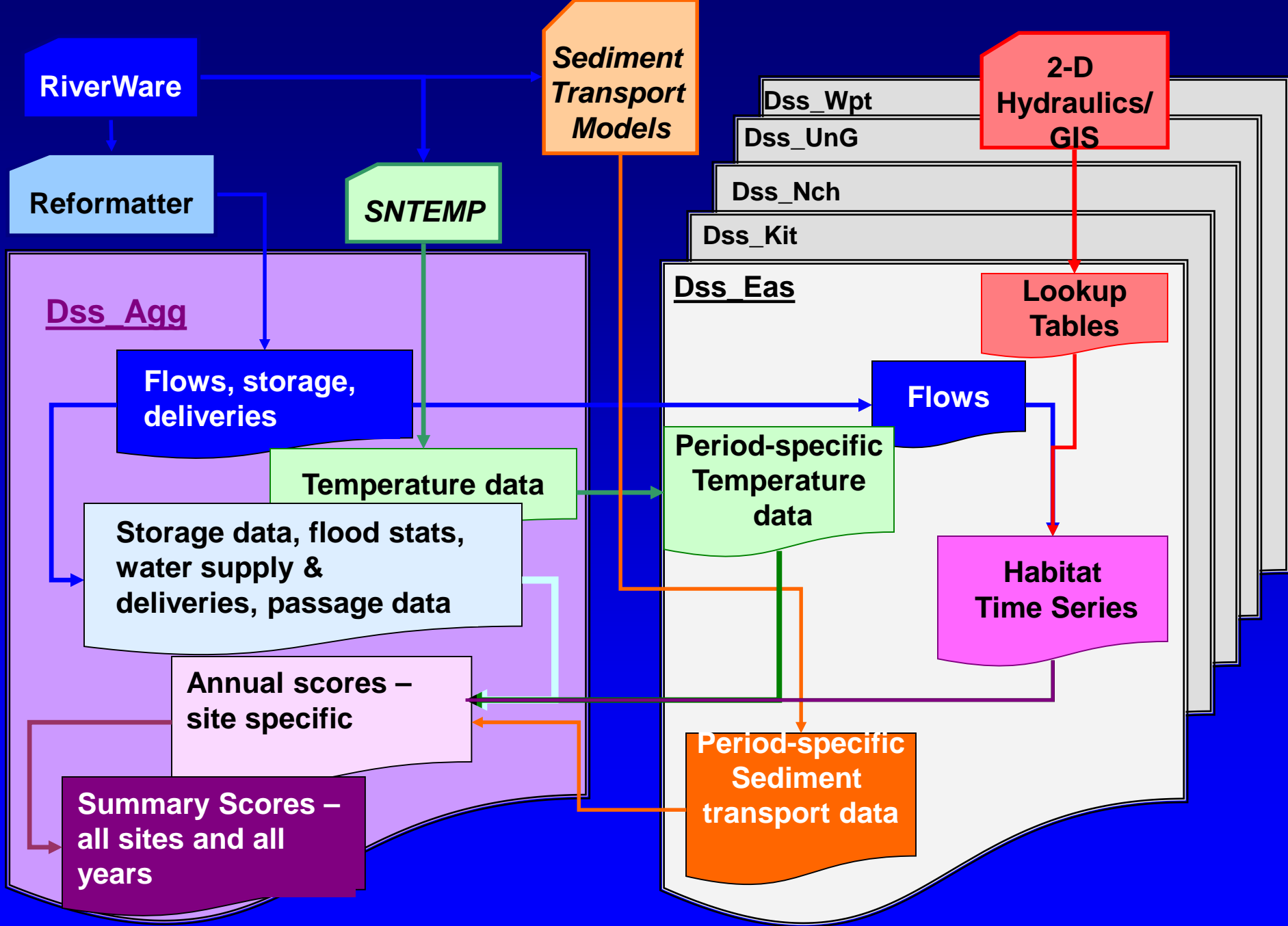
DSS OUTPUTS

- **Summary scores pages**
- **Annual scores pages**
- **Duration series plots**
- **Flow and temperature duration curves**
- **Flow and storage time series plots**

YRDSS Summary Page, Illegible Version

	RunDate:	05/18/07			Start date		End date
	Baseline:	NoAction_new			10/1/1981	to	9/30/2003
Summary	Alternative:	Alternative_1_new			10/1/1981	to	9/30/2003

Stream Reach

Resource Category	Time Window	Easton Base	Alternative	Pct Cdg	Kittitas Base	Alternative	Pct Cdg	Naches Base	Alternative	Pct Cdg	Union Gap Base	Alternative	Pct Cdg	Wapato Base	Alternative	Pct Cdg
Spring Chinook																
Redd Scour day count	Sep-15-Mar-31	14.0	11.0	-21.4%	244.0	234.0	-4.1%	103.0	97.0	-5.8%						
Spawning/incubation*	Sep-15-Mar-31	46.7	46.3	-1.0%	24.8	25.0	0.6%	24.4	26.1	7.2%						
Fry	Mar-01 - May-31	2.7	2.8	0.7%	1.7	1.7	-0.7%	2.8	2.8	-0.5%						
Sub-yearling (Spring-summer)	Jun-01 - Sep-30	49.0	48.3	-1.4%	15.0	15.0	0.3%	32.6	32.8	0.5%						
Sub-yearling (winter)	Oct-01 - May-31	8.6	8.8	1.4%	4.0	3.9	-0.8%	5.2	5.2	-0.1%	51.1	51.0	0%	49.5	49.0	-1%
Adult holding	Apr-01 - Sep-30	7.3	7.2	-0.5%	6.6	6.6	0.2%	7.3	7.3	0.9%						
Fall Chinook																
Redd Scour day count	Oct-01-Mar-31										833.0	826.0	-0.8%	733.0	720.0	-1.8%
Spawning/incubation*	Oct-01-Mar-31										18.1	17.2	-5.0%	11.4	6.6	-42.3%
Fry	Mar-01 - Apr-30										6.9	7.0	0.9%	7.4	7.5	0.8%
Sub-yearling (Spring-summer)	May-01 - Jun-01										38.9	38.1	-1.9%	33.0	32.3	-2.0%
Coho																
Redd Scour day count	Nov-01-Mar-31	9.0						86.0	84.0	-2.3%	762.0	756.0	-0.8%	662.0	649.0	-2.0%
Spawning/incubation*	Nov-01-Mar-31	39.9						5.3	6.5	24.0%	5.4	4.8	-10.3%	2.9	1.6	-45.7%
Fry	Apr-01 - May-30	2.9						3.0	3.0	-0.3%	6.7	6.9	1.7%	7.4	7.5	1.4%
Sub-yearling (Spring-summer)	Jun-01 - Sep-30	17.7						7.9	8.0	0.9%	26.2	25.8	-1.7%	21.9	21.3	-2.7%
Sub-yearling (winter)	Oct-01 - Apr-30	5.4						3.6	3.6	-0.4%	43.8	43.7	-0.3%	42.9	42.6	-0.7%
Steelhead																
Redd Scour day count	Mar-01-Jul-31	1.3						341.0	332.0	-2.6%	1294.0	1125.0	-13.1%	1294.0	1125.0	-13.1%
Spawning/incubation*	Mar-01-Jul-31	54.3						30.9	33.7	9.2%	12.8	13.1	2.5%	9.4	5.4	-42.4%
Fry	Jul-01 - Aug-30	4.5						3.4	3.4	-0.5%	7.6	7.7	1.1%	8.1	8.1	0.0%
Sub-yearling (Spring-summer)	Sep-01 - Sep-30	61.2						46.0	46.3	0.7%	39.8	39.8	0.0%	40.0	40.0	0.1%
Sub-yearling (winter)	Oct-01 - Apr-30	7.7						4.8	4.8	-0.1%	46.7	46.6	-0.4%	45.7	45.4	-0.7%
Sub-adults	May-01 - Aug-30	57.1	56.9	-0.3%	19.1	19.2	0.0%	51.0	51.2	0.5%	42.2	41.8	-0.9%	40.4	40.4	0.0%
Adult holding	Sep-01 - Mar-31	22.5	22.6	0.4%	9.7	9.8	0.6%	11.1	11.1	0.4%	20.6	20.5	-0.6%	19.7	19.5	-1.0%
Resident Rainbow																
Redd Scour day count	Feb-01-Jul-31	1.0	1.0	0.0%	328.0	362.0	10.4%	273.0	266.0	-2.6%	825.0	713.0	-13.6%			
Spawning/incubation*	Feb-01-Jul-31	48.1	48.2	0.1%	18.8	19.2	1.9%	30.9	33.7	9.2%	6.5	5.6	-13.7%			
Fry	Jul-01 - Aug-30	5.6	5.4	-3.6%	2.5	2.5	0.3%	4.3	4.3	-0.4%	7.6	7.7	1.1%			
Sub-yearling (Spring-summer)	Sep-01 - Sep-30	60.5	60.3	-0.3%	21.1	21.2	0.4%	45.8	46.2	0.7%	38.8	38.8	0.0%			
Sub-yearling (winter)	Oct-01 - Apr-30	9.0	9.2	1.4%	4.4	4.3	-0.7%	6.3	6.2	-0.1%	54.4	54.2	-0.3%			
Sub-adults	May-01 - Aug-30	30.3	30.0	-1.1%	8.1	8.1	0.1%	17.1	17.1	-0.5%	30.4	29.9	-1.4%			
Bull Trout																
Redd Scour day count	Oct-01 - Mar-31	14.0	11.0	-21.4%	244.0	234.0	-4.1%	102.0	96.0	-5.9%						
Spawning/incubation	Oct-01 - Mar-31	36.0	36.6	1.6%	10.9	11.5	5.2%	4.5	5.2	15.5%						
Fry	Oct-01 - Nov-30	6.1	6.1	0.8%	2.1	2.1	-0.3%	4.6	4.6	0.4%						
Sub-yearling (Spring-summer)	Jun-01 - Sep-30	17.6	17.6	-0.1%	20.5	20.6	0.2%	64.6	65.2	0.9%						
Sub-yearling (winter)	Oct-01 - May-31	8.5	8.6	1.1%	4.2	4.2	-0.7%	6.3	6.3	-0.3%						

Resevoir outmigration inseason days impassible		Base	Alternative	Pct Chg
Kaches	Jul-15 - Sep-15	19	20	6.6%
Keechelus	Jul-15 - Sep-15	38	40	4.7%
Rimrock	Jul-01 - Aug-15	2	4	100.0%

Flood Metrics		Easton Base	Alternative	Pct Chg	Kittitas Base	Alternative	Pct Chg	Naches Base	Alternative	Pct Chg	Union Gap Base	Alternative	Pct Chg	Base
Overbank flow < 100 yr flood	days	97	96	-1.0%	90	83	-7.8%	132	126	-4.5%	270	246	-8.9%	
Damaging flood (>= 100 yr)	days	0	0	0.0%	0	0	0.0%	0	0	0.0%	0	0	0.0%	

Water Division Deliveries		April Base	Alternative	Pct Chg	May Base	Alternative	Pct Chg	June Base	Alternative	Pct Chg	July Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg
Average for Month Proration (%)		90%	90%	0.0%	88%	88%											87%	87%	0.0%
TWSA (af) Average of 1st of Months		2887943	2887943	0.0%	2477995	2477995											591374	591374	0.0%

Reservoir storage End of Season Carry Over		Bumping Base	Alternative	Pct Chg	Cle Elum Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Wymer Base	Alternative	Pct Chg
Average	(af)	9746	9227	-5.3%	96842	86685	-10.5%	80051	73231	-8.5%	31216	26630	-14.7%	52151	41872	-19.7%	0	0	Base, Alt = 0

Sediment Transport		Easton Base	Alternative	Pct Chg	Kittitas Base	Alternative	Pct Chg	Base				Pct Chg
Fine Material Transport	Total tons	1374746	1365021	-0.7%	3773797	3753894	-0.5%	2660				0.6%
Geomorphic Adjustment	Total work	687373	682511	-0.7%	1807698	1802147	-0.3%	1284062	1259687		6.8%	3.7%
Armour Disruption	Day count	7	7	0.0%	328	303	-7.6%	210	201	-4.3%	1525 1397 -8.4% 894 835	-6.6%

Sites

Target Species, Life Stages, and Hydroperiods

Habitat Scores

Reservoir Outmigration Scores

Overbank Flows and Floods

Water Deliveries and Storage Scores

Sediment Transport Scores

Habitat Time Series

- Floodplain reaches – Easton, Kittitas, Naches, Union Gap, and Wapato.

- Target species – Spring Chinook, Fall Chinook, Coho, Steelhead, Rainbow Trout, Bull Trout.

- Life Stages (variable by species) – Spawning and Incubation, Fry, Sub-yearling (winter and summer), Yearling, Adult.

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Derivation of a Habitat Time Series

A

Time step 190
Flow = 2,121 cfs

B

Flow = 2,121 cfs
Area = 6.24 ha

C

Time step 190
Area = 6.24 ha

USGS
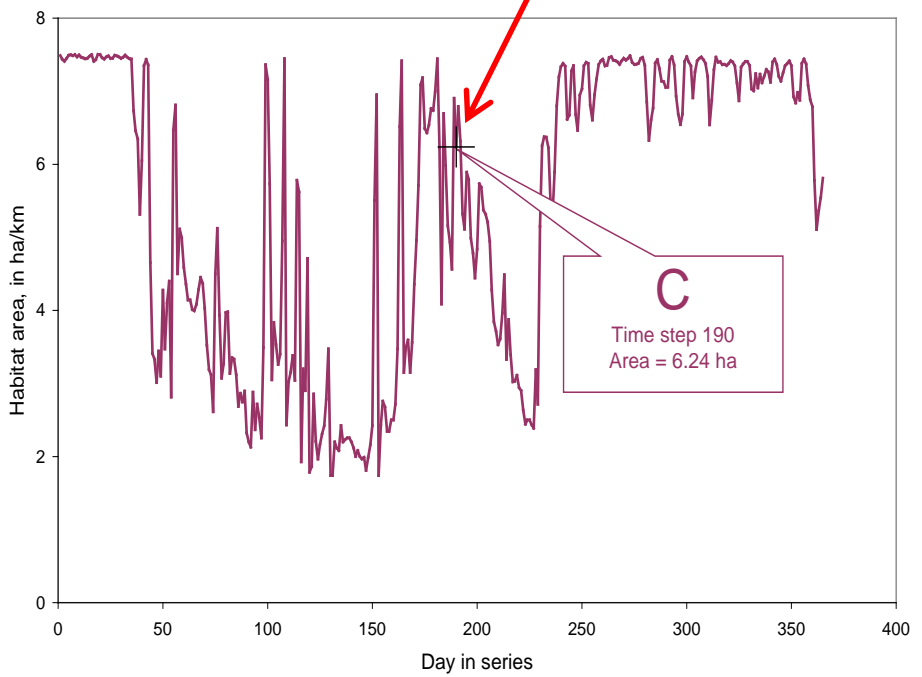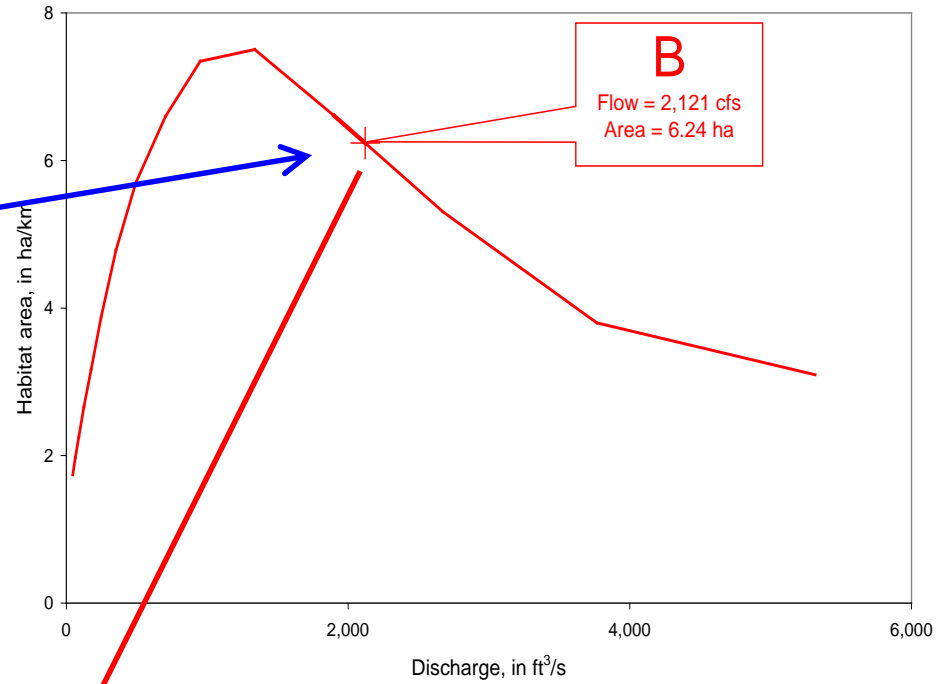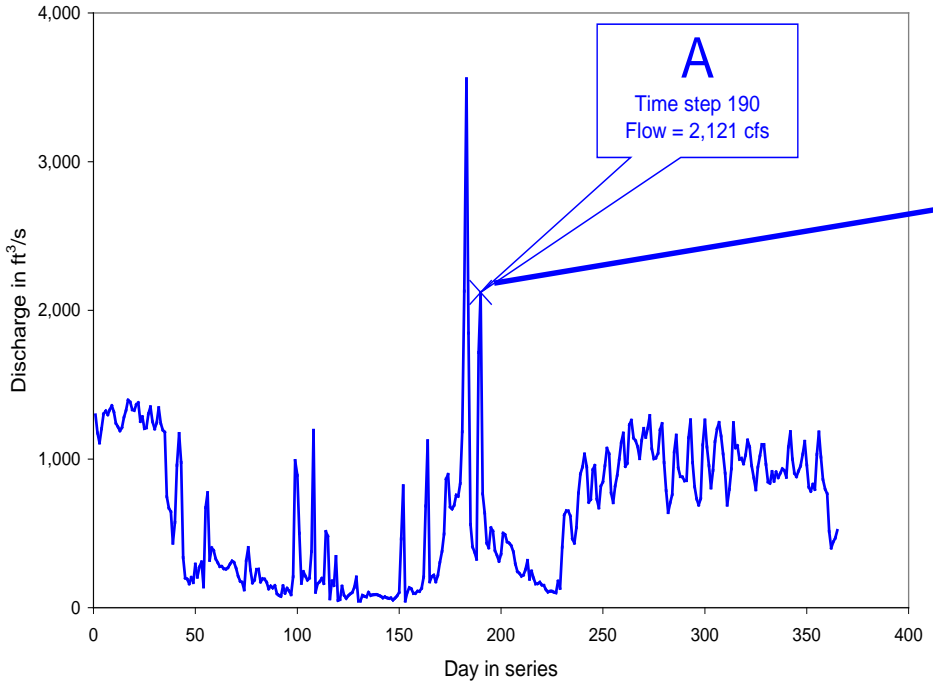
Derivation of a Habitat Versus Flow Functions

- Hydraulics Simulated Using 2-D Hydrodynamic Models: Range of Discharges = Central 98 Percent of Historic Flows.

- Classifications of Suitable Habitat for Each Life Stage Determined by Delphi Method.

- Hydraulic Characteristics Reclassified as Suitable Habitat by Geographic Information System (ArcGis).

- Areas of Suitable Habitat Determined for Each Flow and Compiled into Lookup Tables.

Example Output from 2-D Hydrodynamic Model – Depth Distribution at Easton with Q = 300 cfs.

Depth range (ft)
- < 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- > 12
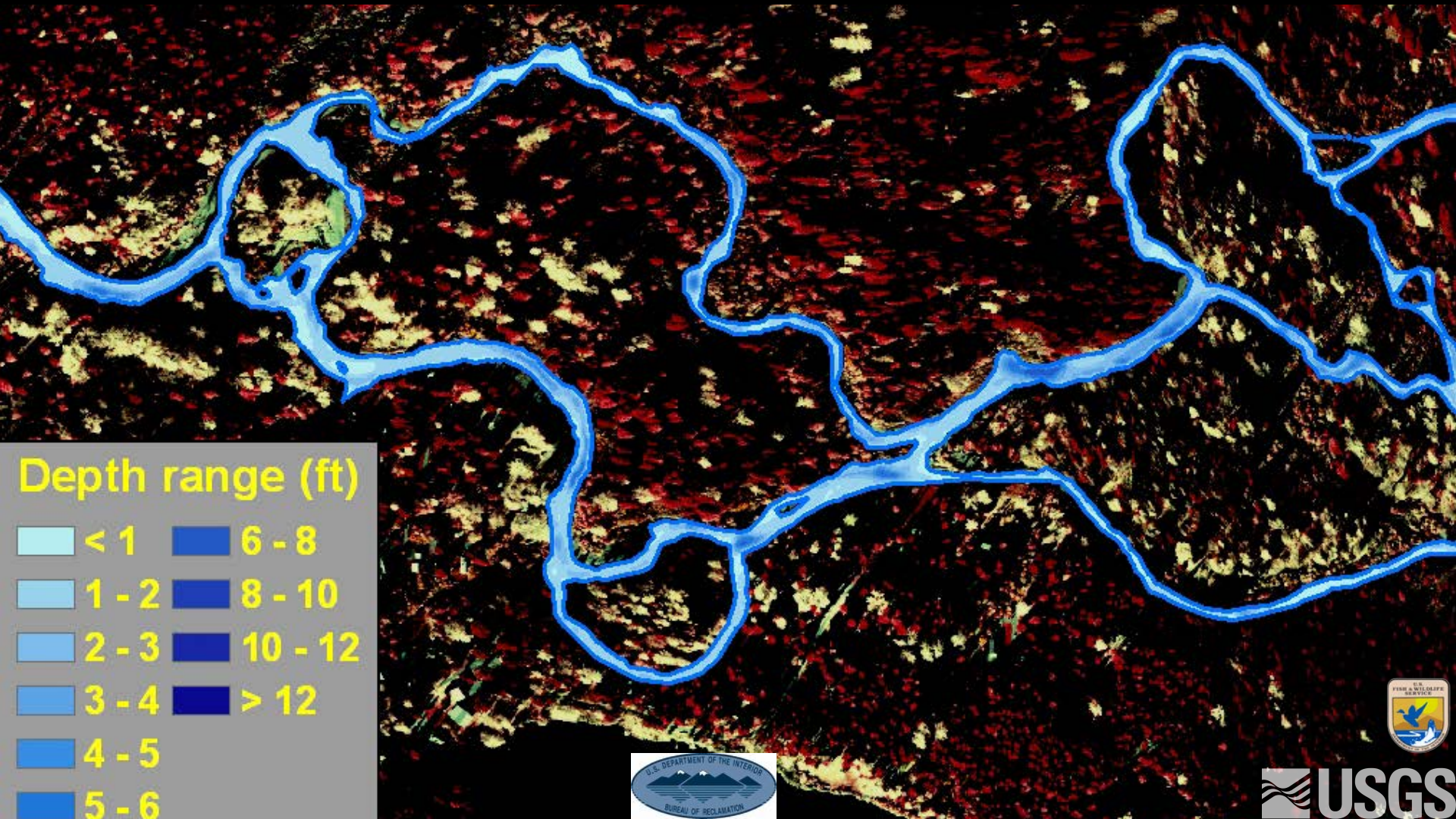
Example Output from GIS Reclassification Model – Steelhead Subyearling Habitat Distribution at Easton with Q = 300 cfs.

Habitat type

- Steelhead subyear summer
- Steelhead subyear winter
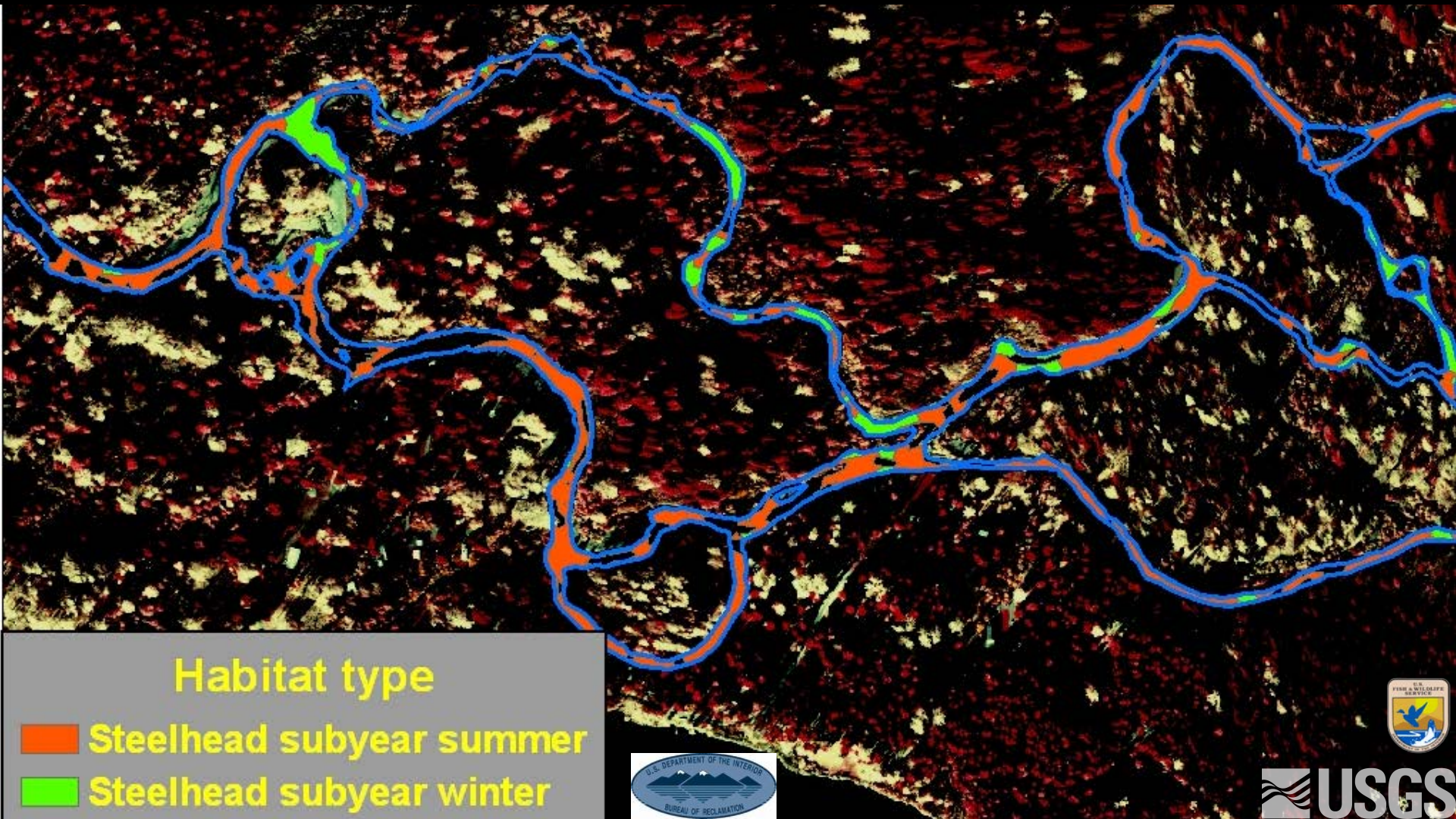
Special Case for Spawning and Incubation Habitat

- Habitat Suitability Determined by Suitable Incubation Conditions Persisting in Locations Where Spawning Could Have Occurred.

- Quantified as the Intersection of Suitable Spawning Areas at Q1 and Suitable Incubation Areas at Q2: For All Combinations of Q1 and Q2.

Special Case for Spawning and Incubation Habitat

Spawning/Incubation Intersection Map

Persistent habitat

- Suitable spawning @ 1100
- Suitable incubation @ 150
- Suitable at both flows

USGS
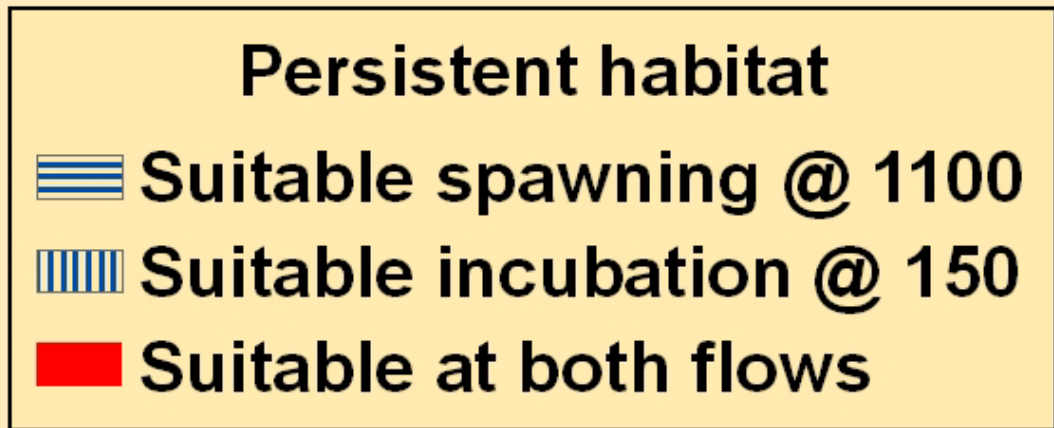
Portion of YRDSS Annual Scores Page For Spring Chinook Habitat at Easton

Spring Chinook	Redd Scour			Spawning/incubation			Fry			Sub-yearling (Spring-summer)			Sub-yearling (winter)		
Water Year	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg	Base	Alternative	Pct Chg
1982	0	0	Base, Alt = 0	52.15	47.80	-8.34%	2.40	2.58	7.40%	51.28	51.80	1.03%	6.62	7.45	12.56%
1983	0	0	Base, Alt = 0	46.05	45.12	-2.02%	2.48	2.53	1.91%	60.53	60.53	0.00%	7.39	7.38	-0.17%
1984	0	0	Base, Alt = 0	47.48	45.58	-4.01%	2.68	2.65	-1.11%	44.75	46.86	4.71%	7.05	7.02	-0.39%
1985	0	0	Base, Alt = 0	53.26	53.14	-0.23%	3.10	3.10	0.18%	41.58	42.68	2.66%	11.71	11.77	0.48%
1986	0	0	Base, Alt = 0	55.94	56.08	0.26%	2.53	2.57	1.29%	46.43	42.81	-7.81%	8.91	9.09	2.02%
1987	0	0	Base, Alt = 0	54.66	53.36	-2.38%	2.62	2.62	0.08%	42.52	40.06	-5.78%	9.71	9.81	1.04%
1988	0	0	Base, Alt = 0	56.24	51.54	-8.36%	2.58	2.58	0.06%	50.10	48.82	-2.55%	9.85	10.18	3.37%
1989	0	0	Base, Alt = 0	52.94	52.56	-0.72%	3.18	3.19	0.25%	58.06	51.96	-10.50%	8.00	8.02	0.32%
1990	0	0	Base, Alt = 0	49.14	48.03	-2.26%	2.79	2.73	-2.14%	50.09	48.84	-2.50%	7.44	7.34	-1.41%
1991	5	4	-20.00%	15.45	15.23	-1.46%	2.78	2.79	0.31%	60.53	59.65	-1.45%	6.81	6.66	-2.25%
1992	0	0	Base, Alt = 0	56.00	53.04	-5.28%	2.72	2.95	8.39%	37.89	36.48	-3.73%	7.93	8.51	7.35%
1993	0	0	Base, Alt = 0	52.36	50.56	-3.43%	2.97	2.97	0.08%	38.87	40.21	3.45%	11.47	11.61	1.22%
1994	0	0	Base, Alt = 0	51.22	51.22	0.00%	2.68	2.69	0.37%	45.36	44.68	-1.49%	10.74	10.76	0.27%
1995	0	0	Base, Alt = 0	51.66	51.26	-0.76%	2.69	2.69	0.05%	60.53	60.53	0.00%	7.75	7.75	0.00%
1996	2	3	50.00%	15.59	15.36	-1.46%	2.78	2.75	-1.29%	59.31	59.57	0.43%	7.14	7.20	0.83%
1997	5	4	-20.00%	20.48	29.62	44.63%	2.48	2.53	2.04%	46.75	48.09	2.87%	7.13	7.39	3.58%
1998	0	0	Base, Alt = 0	48.17	50.58	5.02%	2.62	2.58	-1.34%	55.06	56.19	2.04%	8.04	8.15	1.32%
1999	0	0	Base, Alt = 0	53.01	52.88	-0.25%	2.48	2.51	1.12%	43.87	45.26	3.15%	6.86	6.93	1.03%
2000	2	0	-100.00%	42.35	41.60	-1.78%	2.87	2.88	0.17%	46.28	44.98	-2.81%	8.56	8.79	2.62%
2001	0	0	Base, Alt = 0	50.75	50.29	-0.89%	2.93	2.87	-1.98%	35.97	35.22	-2.07%	11.90	11.79	-0.93%
2002	0	0	Base, Alt = 0	54.07	54.07	0.00%	2.97	2.99	0.59%	46.63	47.46	1.78%	8.90	8.94	0.45%
2003	0	0	Base, Alt = 0	49.50	49.57	0.14%	2.77	2.77	0.13%	55.06	49.77	-9.61%	10.05	10.07	0.23%

Derivation of Temperature Data

- Stream Network Temperature Model (SNTEMP) Designed and Calibrated for Upper Yakima Basin by USGS Washington Water Science Center.

- Daily Flows and Reservoir Releases Input from RiverWare for Baseline and Alternative Operations.

- Scoring Based on Changes in Max/Min During the Hydroperiod Defined for Each Life Stage.

Portion of YRDSS Annual Scores Page For Water Temperatures at Easton

Maximum Temp

Spawning			Incubation			Fry			Sub-yearling (Spring-summer)			Sub-yearling (winter)		
Base	Alternative	Alt - Base	Base	Alternative	Alt - Base	Base	Alternative	Alt - Base	Base	Alternative	Alt - Base	Base	Alternative	Alt - Base
15	14	-0.24	13	13	-0.21	17	17	-0.28	18	18	-0.30	17	17	-0.28
13	14	0.96	12	13	0.85	15	17	1.11	17	18	1.20	15	17	1.11
14	14	0.60	12	13	0.53	16	17	0.70	17	18	0.75	16	17	0.70
15	15	0.12	13	14	0.11	18	18	0.14	19	19	0.15	18	18	0.14
13	14	0.96	12	13	0.84	15	17	1.11	17	18	1.20	15	17	1.11
14	13	-1.08	13	12	-0.96	17	15	-1.25	18	17	-1.35	17	15	-1.25
11	12	0.36	10	10	0.32	13	14	0.42	14	15	0.45	13	14	0.42
12	13	0.12	11	11	0.11	14	15	0.14	16	16	0.15	14	15	0.14
14	14	0.72	12	13	0.64	16	17	0.83	17	18	0.90	16	17	0.83
14	14	0.24	12	12	0.21	16	16	0.28	17	17	0.30	16	16	0.28
13	14	0.96	11	12	0.85	15	16	1.11	16	17	1.20	15	16	1.11
12	12	0.24	10	11	0.21	14	14	0.28	15	15	0.30	14	14	0.28
13	14	0.60	12	12	0.53	15	16	0.70	17	17	0.75	15	16	0.70
13	14	0.96	12	13	0.85	15	17	1.11	17	18	1.20	15	17	1.11
12	13	0.48	11	11	0.42	14	15	0.56	15	16	0.60	14	15	0.56
12	11	-0.36	10	10	-0.32	14	13	-0.42	15	14	-0.45	14	13	-0.42
11	10	-0.84	10	9	-0.74	13	12	-0.97	14	13	-1.05	13	12	-0.97
13	12	-1.19	12	11	-1.06	15	14	-1.39	17	15	-1.50	15	14	-1.39
14	14	0.00	13	13	0.00	17	17	0.00	18	18	0.00	17	17	0.00
12	12	0.12	10	10	0.11	14	14	0.14	15	15	0.15	14	14	0.14
15	15	0.24	13	13	0.21	17	18	0.28	19	19	0.30	17	18	0.28
12	11	-1.08	11	10	-0.96	14	13	-1.25	15	14	-1.35	14	13	-1.25

Overbank Flow and Floods

- Overbank flows considered beneficial, but damaging floods detrimental.

- Overbank flow defined as maximum daily flow with 1.67 year recurrence interval (Default).

- Damaging flood defined as maximum daily flow with 25 year recurrence interval (Default).

- Scoring based on frequency of either under baseline and alternative.

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Deliveries and Exports

- **Total Water Supply Available (TWSA) and Proration Rates derived directly from RiverWare.**

- **Scoring based on percentage differences in TWSA and Proration for baseline and alternative, monthly, from April through September.**

Sediment Transport (under construction)

- **Four aspects considered:**
  - **Redd Scour**
  - **Fine Sediment Transport**
  - **Armour Disruption and**
  - **Geomorphic Processes.**

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- **Redd Scour – Scored as Frequency of Flows During Spawning/Incubation Window, Capable of Moving Redd Substrates.**

- **Fine Sediment Transport – Scored as Difference in Total Mass Transport of Sand and Smaller Sized Sediment.**

- **Armour Disruption – Scored as Frequency of Flows Capable of Mobilizing the Armour Layer.**

- **Geomorphic Adjustment – Scored as Annual Sum of Geomorphic Work Done.**

Portion of YRDSS Summary Scores Page For Remaining Decision Variables

Reservoir Outmigration

inseason days impassible		Base	Alternative	Pct Chg
Kachess	Jul-15 - Sep-15	19	20	6.6%
Keechelus	Jul-15 - Sep-15	38	40	4.7%
Rimrock	Jul-01 - Aug-15	2	4	100.0%

Flood Metrics

		Easton		
		Base	Alternative	Pct Chg
Overbank flow < 100 yr flood	days	97	96	-1.0%
Damaging flood (>= 100 yr)	days	0	0	0.0%

Water Division Deliveries

		April		
Proration (%)		Base	Alternative	Pct Chg
Average for Month		90%	90%	0.0%
TWSA (af)				
Average of 1st of Months		2887943	2887943	0.0%

Reservoir storage

		Bumping		
End of Season Carry Over	(af)	Base	Alternative	Pct Chg
Average		9746	9227	-5.3%

Sediment Transport

		Easton		
		Base	Alternative	Pct Chg
Fine Material Transport	Total tons	1374746	1365021	-0.7%
Geomorphic Adjustment	Total work	687373	682511	-0.7%
Armour Disruption		7	7	0.0%

Current Status of the YRDSS

- Habitat Maps and Lookup Tables Completed for Easton, Kittitas, Naches, and Union Gap. Wapato Nearly Done.

- Sediment Transport Algorithms Under Development by Reclamation's Denver Technical Center.

- Temperature Model Calibrated and Awaiting RiverWare Results.

- RiverWare Baseline (No Action Case) Completed. Alternatives Including Current Operations, Wymer + Exchange, Wymer only (Two Versions), and Black Rock Under Development.

Future Status of the YRDSS

• Prototype Software and Draft User Documentation to be Completed by September 30, 2007.

• USGS Open-File Report to be Completed in Early FY 2008.

• Expansion of YRDSS to Include Lower River Proposed, but not Currently Funded.

Collaborators and Contributors

- USGS
  - -- Fort Collins Science Center
  - -- Columbia River Research Laboratory
  - -- Washington Water Science Center

- U.S. Fish and Wildlife Service

- Bureau of Reclamation
  - -- Yakima Field Office
  - -- Denver Technical Center

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