Performance Measure Review

Non Treaty Storage Scenario Evaluation

BC Hydro

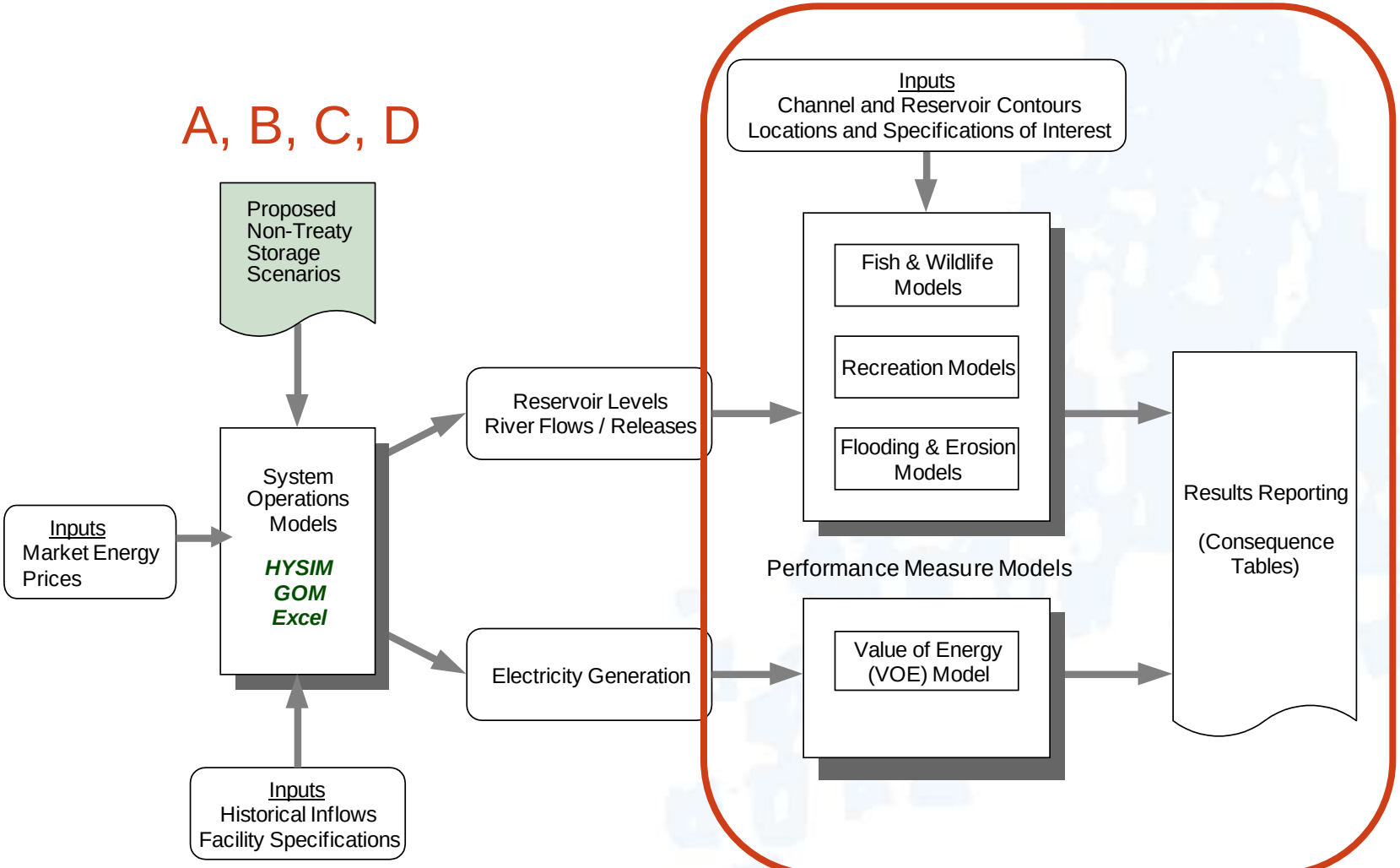
Non Treaty Storage Process

Stakeholder Forum Session #1

Castlegar, BC

October 26-27, 2010

Modelling


A, B, C, D
Proposed Non-Treaty Storage Scenarios
Inputs
Market Energy Prices
System Operations Models
HYSIM
GOM
Excel
Inputs
Historical Inflows
Facility Specifications
Reservoir Levels
River Flows / Releases
Electricity Generation
Inputs
Channel and Reservoir Contours
Locations and Specifications of Interest
Fish & Wildlife Models
Recreation Models
Flooding & Erosion Models
Performance Measure Models
Value of Energy (VOE) Model
Results Reporting
(Consequence Tables)

Performance Measures – Background

- Most developed during the WUP (but some are new)
- Subcommittees formed for each interest area
- Based on local knowledge & interests, available data, and new studies

- Useful tools for scenario evaluation – linking changes in water management to interests/values; *emphasis on relative differences rather than absolutes*
- Will be updated over time to accommodate change, E.g.:
  - New information emerges from WLR implementation
  - Stakeholder interests / understanding evolves

Minimum Significant Increment of Change

- Used during WUP as a tool to support evaluation of relative performance among alternatives
- Indicates the amount by which any two PM scores must differ before one can be considered to perform “significantly” better than the other
- Does NOT imply whether one difference is more important than another.
- Subjective estimates, accounting for uncertainty in:
  - The calculation of reservoir discharge/elevations.
  - The calculation of the performance measures.
  - The link between the performance measure and the fundamental objective.
  - Measurement error

Performance Measures – Two Types

- Hydrologically based performance measures are available now. These are based solely on system modelling results (i.e., # of days at flow = 50 kcfs).

- Next month, physically based PMs (e.g., reservoir pelagic productivity) and biologically based PMs (e.g., bird habitat availability) will be available.

Physical / Biological PMs – coming in November

KINBASKET RESERVOIR

- Fish Entrainment
- Pelagic Productivity
- Riparian Vegetation
- Dust Contribution Potential
- Heritage – Archaeological Sites (Wind ?)

MID COLUMBIA RIVER

- Riverine: Length, Velocity Changes, Productive Area, White Sturgeon Habitat
- Riparian Vegetation
- Early Summer Nesting Birds
- Fall Migrating Birds

ARROW LAKES RESERVOIR

- Fish Entrainment
- Pelagic Productivity
- Riparian Vegetation

LOWER COLUMBIA RIVER

- Whitefish Egg Loss
- Total Gas Pressure

Performance Measures

KINBASKET RESERVOIR
- Navigation
- Recreation
- Heritage

MID COLUMBIA RIVER
- Recreation

LOWER COLUMBIA RIVER
- Recreation
- Flooding

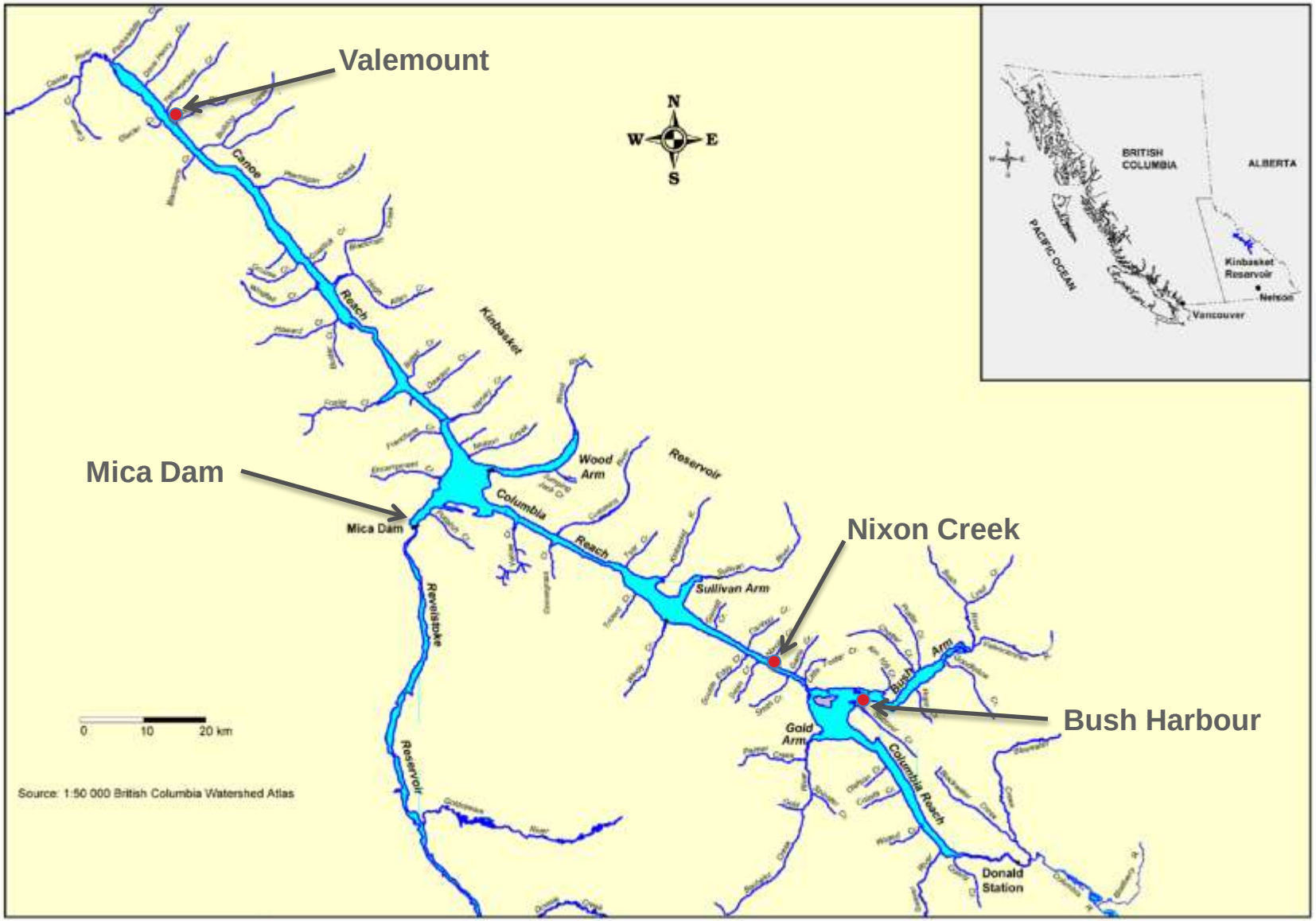
POWER GENERATION
- Financial Value

ARROW LAKES RESERVOIR
- Recreation
- Heritage
- Dust
- Recreation
- Fish
- Vegetation
- Heritage
- Erosion
- Wildlife

Soft Constraints

Our goal today is to review preliminary results, discuss ways to improve, and decide which PMs to carry forward.

Kinbasket Reservoir



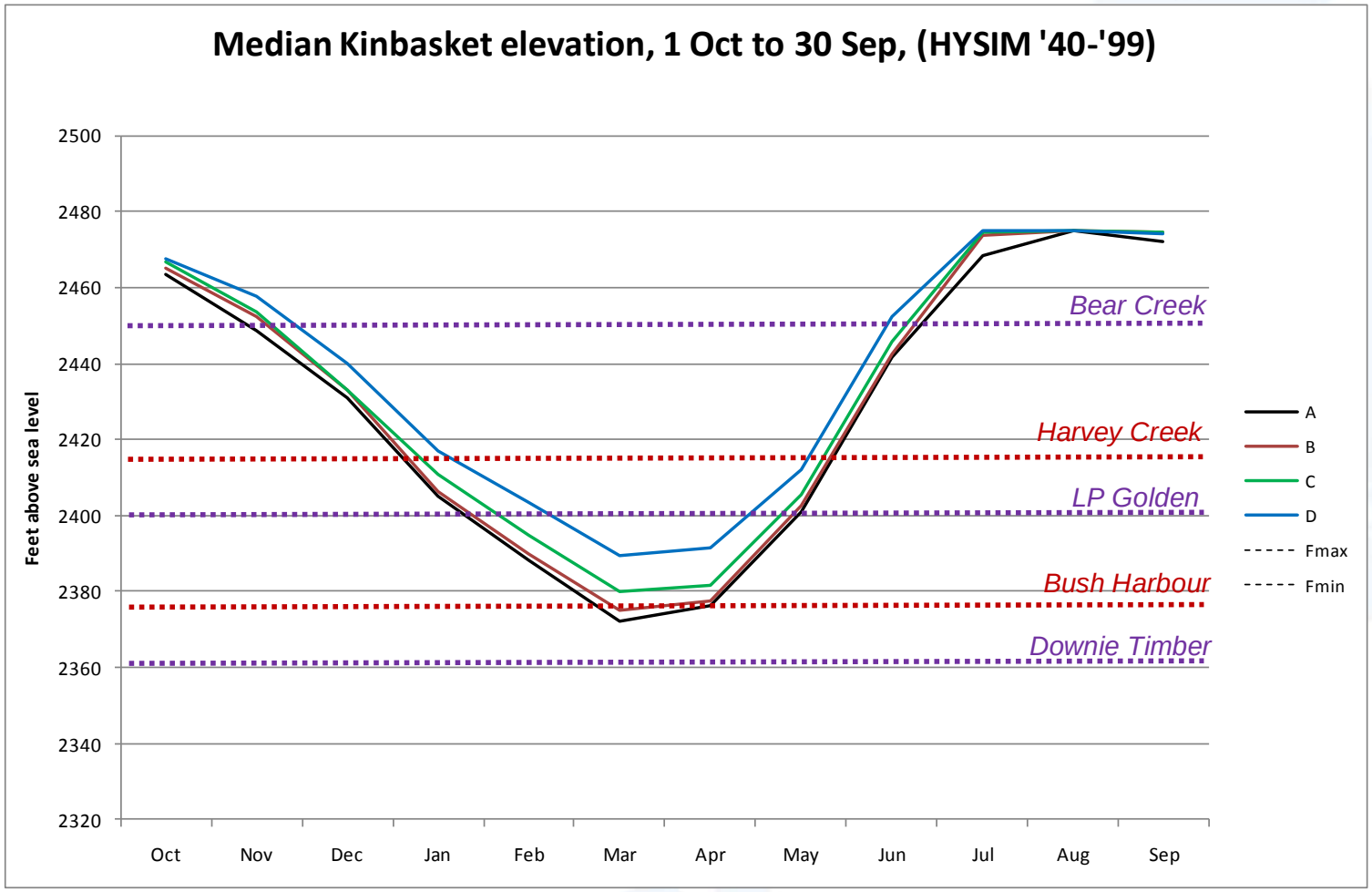
Kinbasket Reservoir – Navigation

DEFINITION

Objective / Location	Performance Measure	Units	Description	MSIC
Navigation/Kinbasket Reservoir	Navigability	# site-days per year	The frequency (in # of site-days per year) that a site is navigable to commercial operators, summed over sites	7 site-days per year

Site	Critical Elevation (ft)	Commercial Operator
Harvey Creek	2415 ft and above	Bell Pole
Bear Creek	2450 ft and above	Mica Marine
Bush Harbour*	2375 ft and above	Mica Marine
Downie Timber	2360 ft and above	Wood River Forest Products
LP Golden	2400 ft and above	LP Golden

Kinbasket Reservoir – Navigation

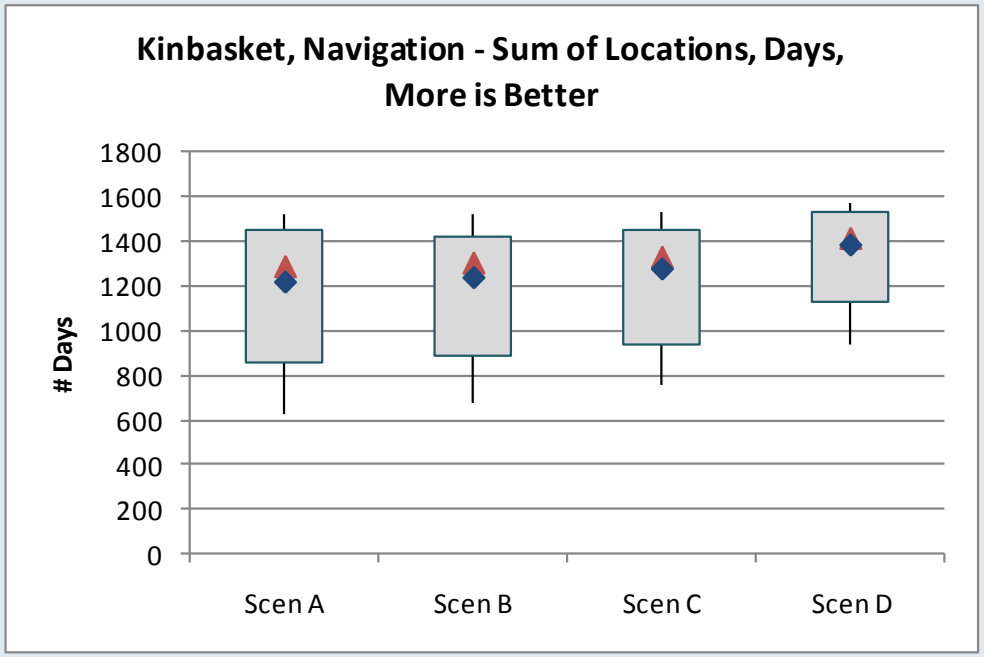


Kinbasket Reservoir – Navigation

RESULTS

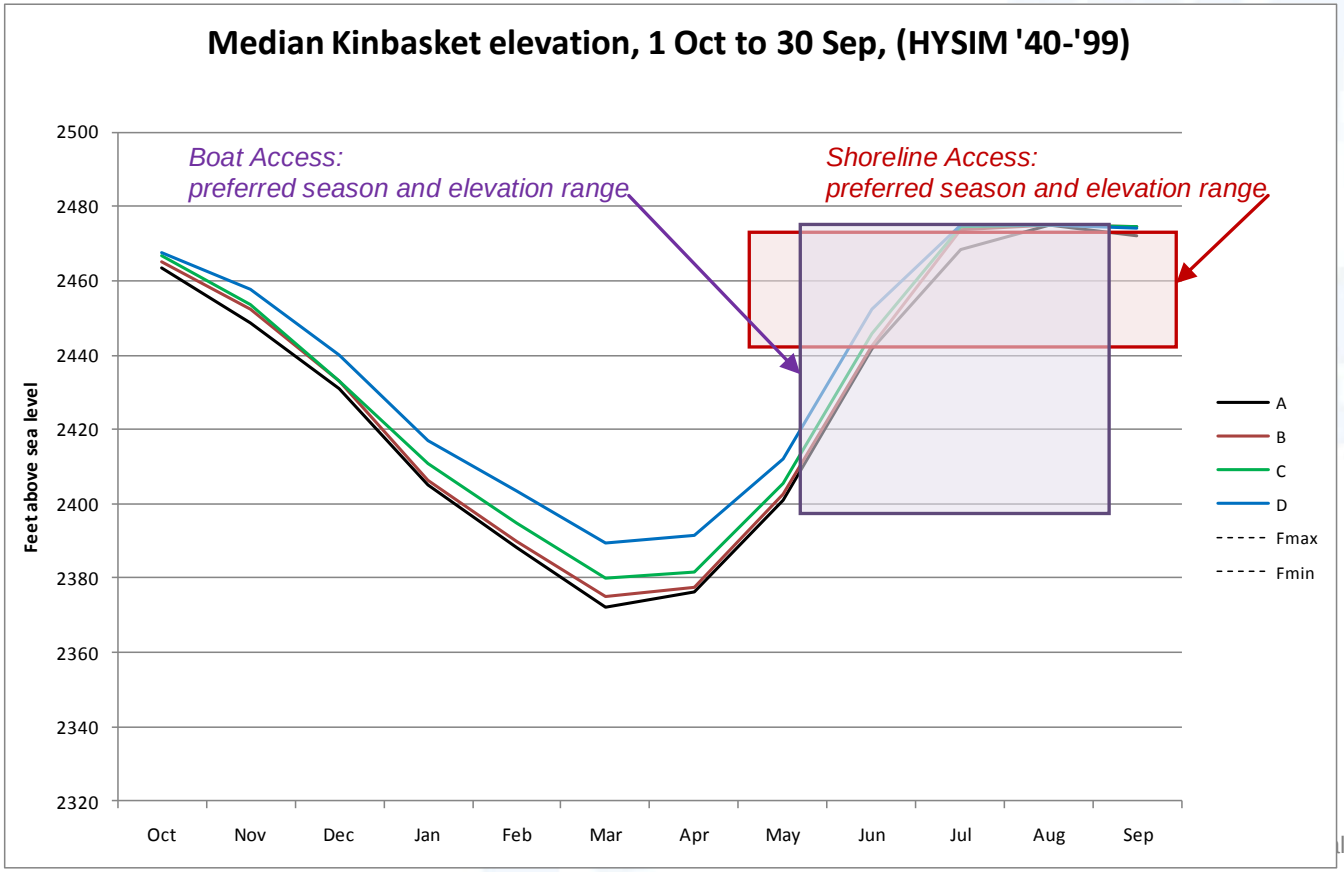
Figure 2: Navigable Site Days – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	1525	1522	1530	1571
90th	1450	1420	1456	1535
Mean	1221	1241	1279	1385
Med	1290	1306	1331	1414
10th	859	891	938	1133
Min	623	679	755	935

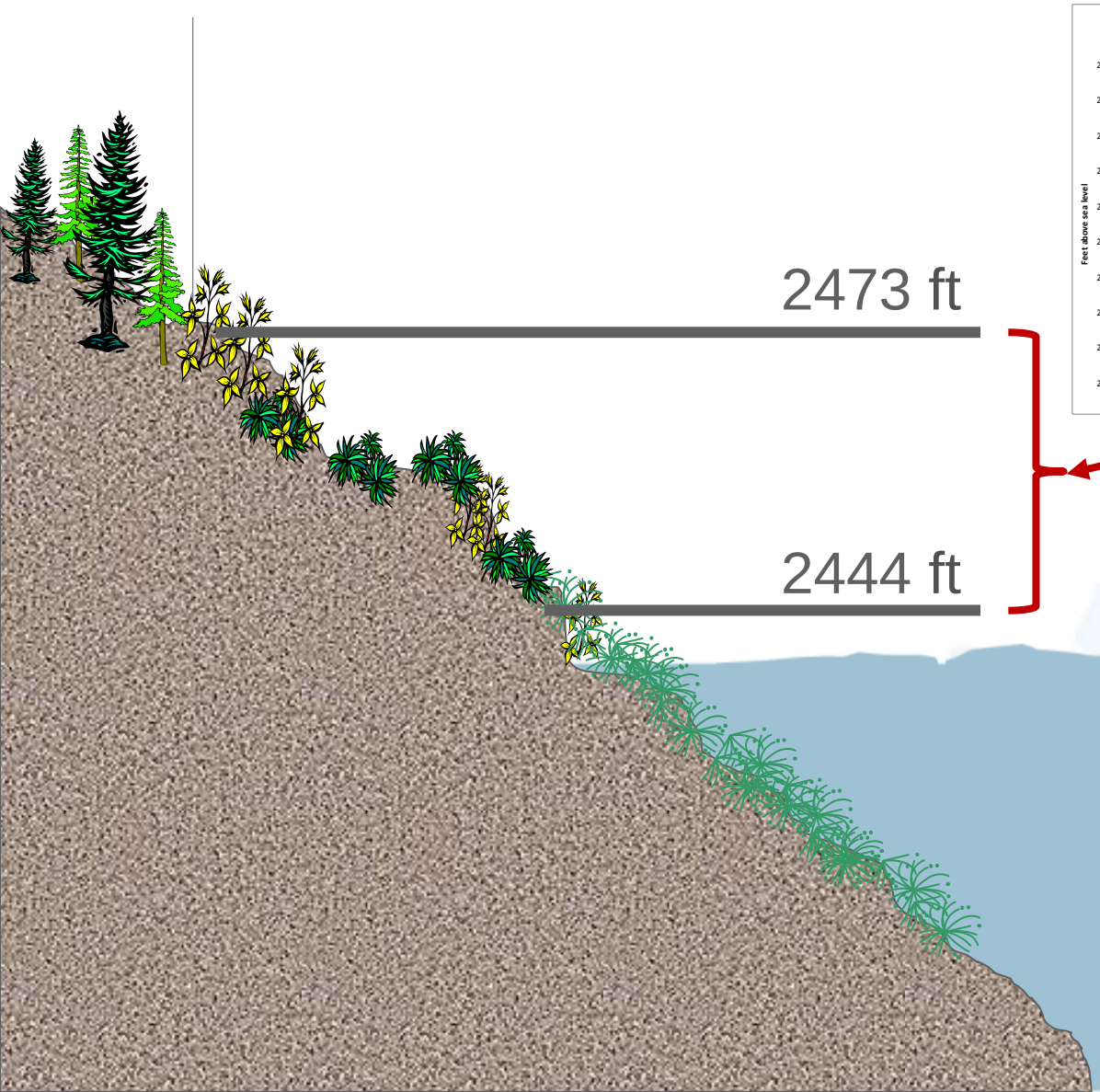


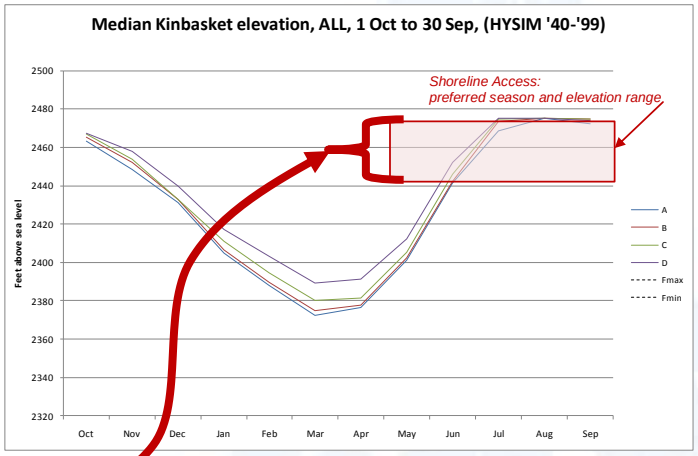
Kinbasket Reservoir – Recreation

Area	Measure	Dates	Critical Elevation Zone	MSIC
Kinbasket Reservoir	Boat Access Days	24 May to 8 Sept	# days between 2395 – 2475 ft	7 days
	Shoreline Access Days	01 May to 30 Sept	# days between 2444 – 2473 ft	7 days



Kinbasket Reservoir – Shoreline Access Days



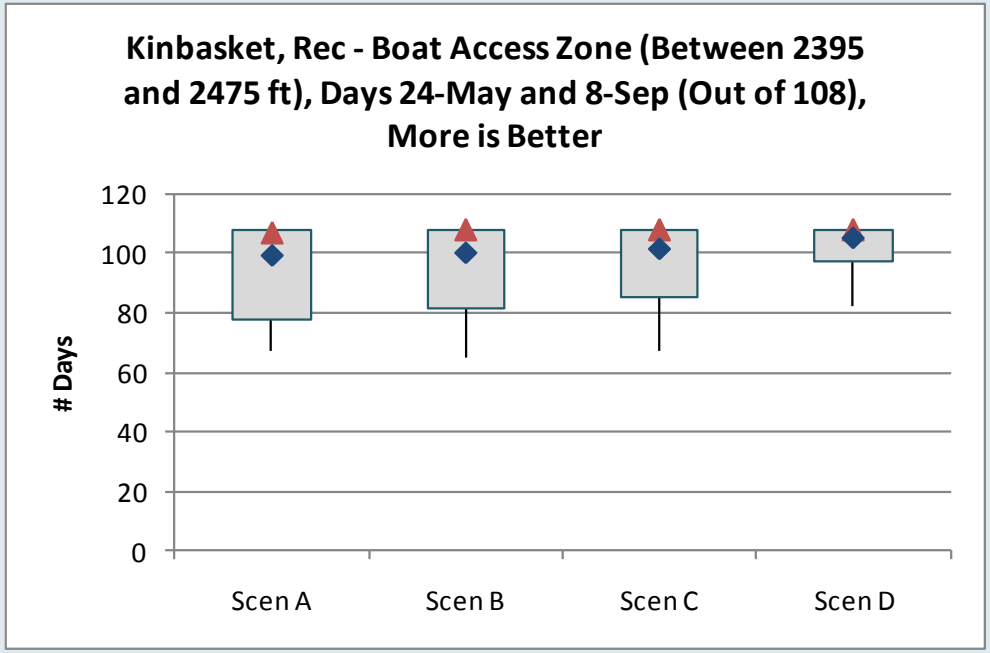


Kinbasket Reservoir – Recreation – Boat Access

RESULTS

Figure 2 a: Boat Access Days – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	108	108	108	108
90th	108	108	108	108
Mean	99	100	102	105
Med	107	108	108	108
10th	78	82	86	98
Min	67	65	67	82

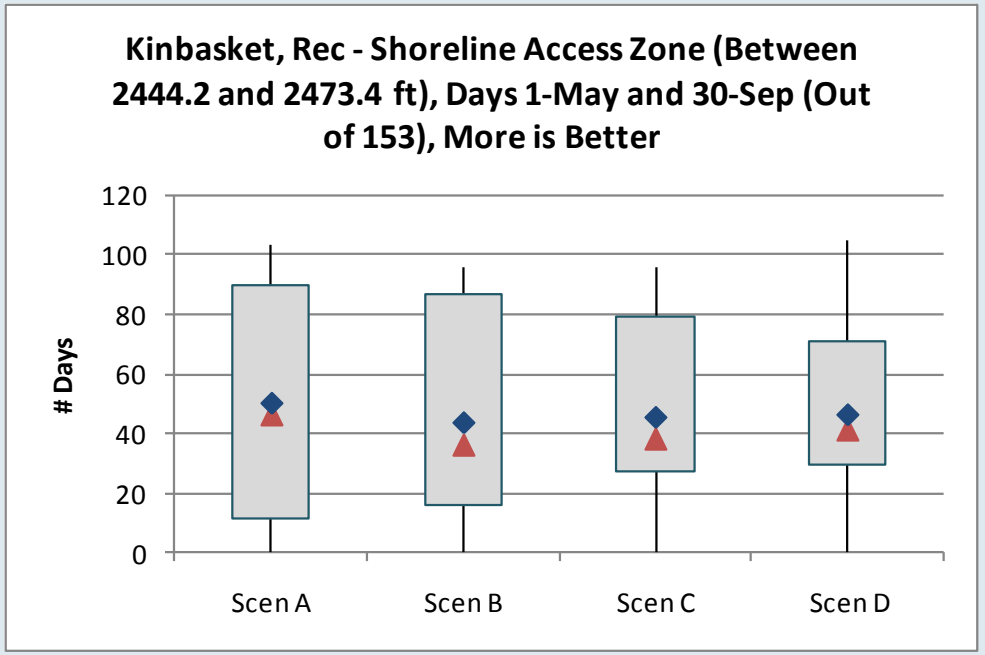


Kinbasket Reservoir – Rec – Shoreline Access

RESULTS

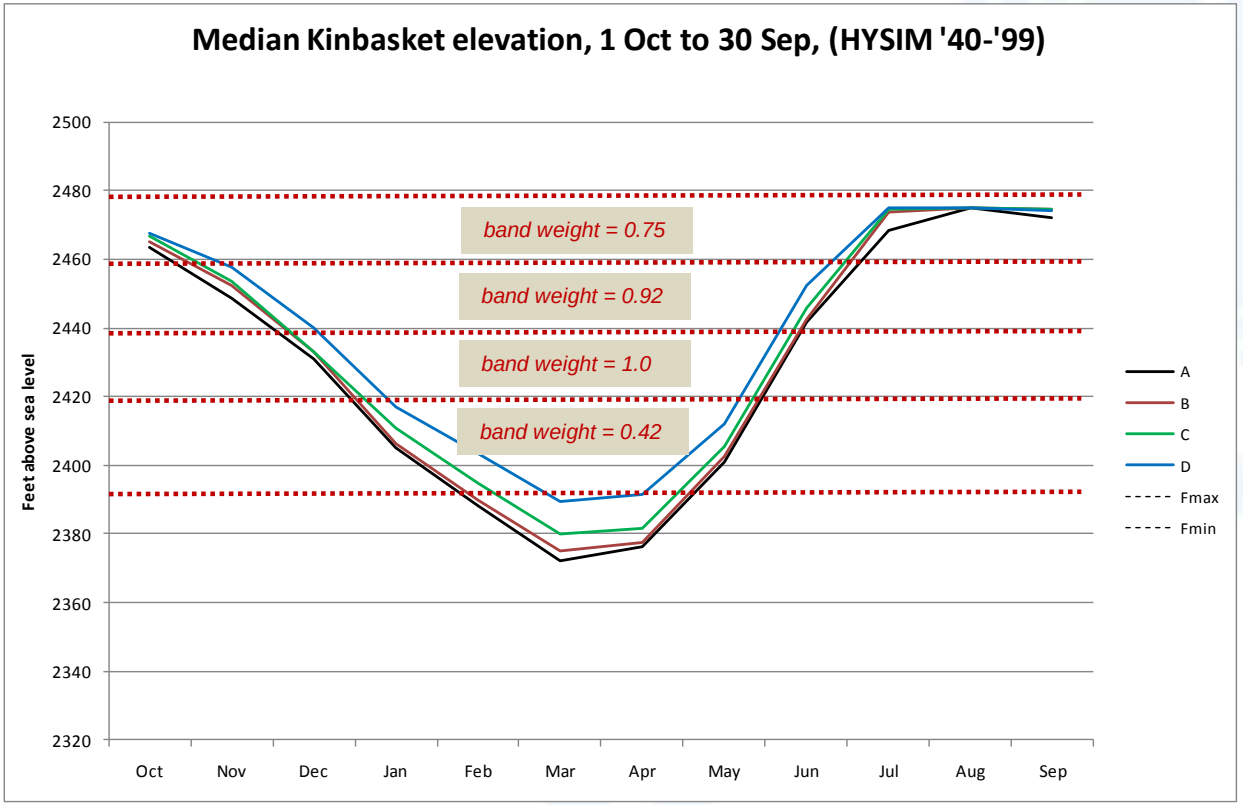
Figure 2 b: Shoreline Access Days – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	103	96	96	105
90th	90	87	79	71
Mean	50	44	45	46
Med	46	36	38	41
10th	12	16	27	30
Min	0	0	0	0



Kinbasket Reservoir – Heritage

	Elevation Range (ft)			
	2391<band<2417	2417<band<2437	2437<band<2457	2457<band<2476
Total sites within elevation band	5	12	11	9
Proportion of sites within band	13.5%	32.4%	29.7%	24.3%
Relative day weight	0.42	1	0.92	0.75

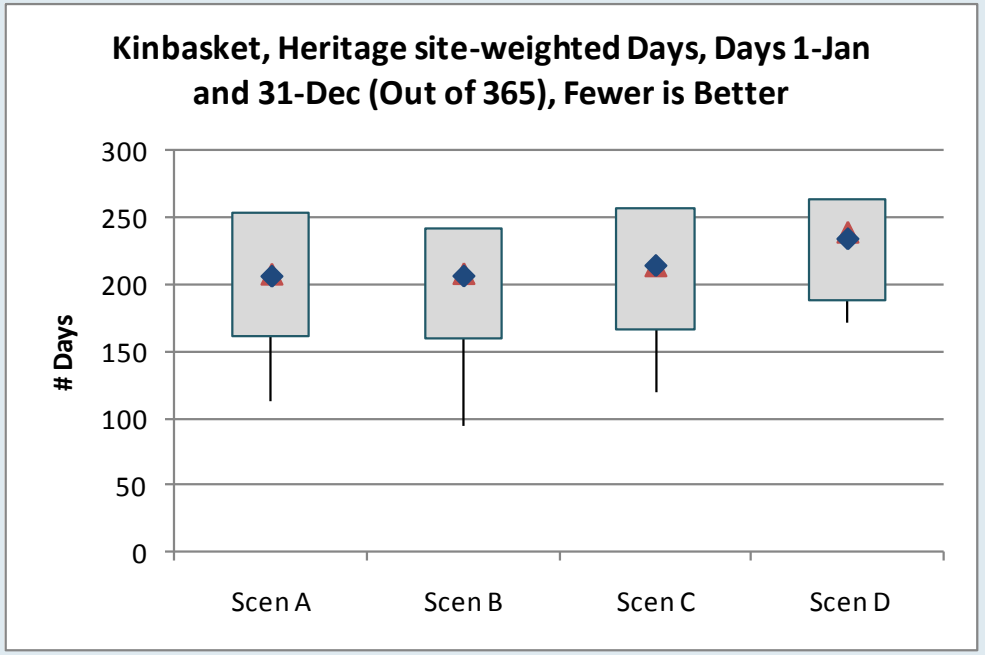


Kinbasket Reservoir – Heritage

RESULTS

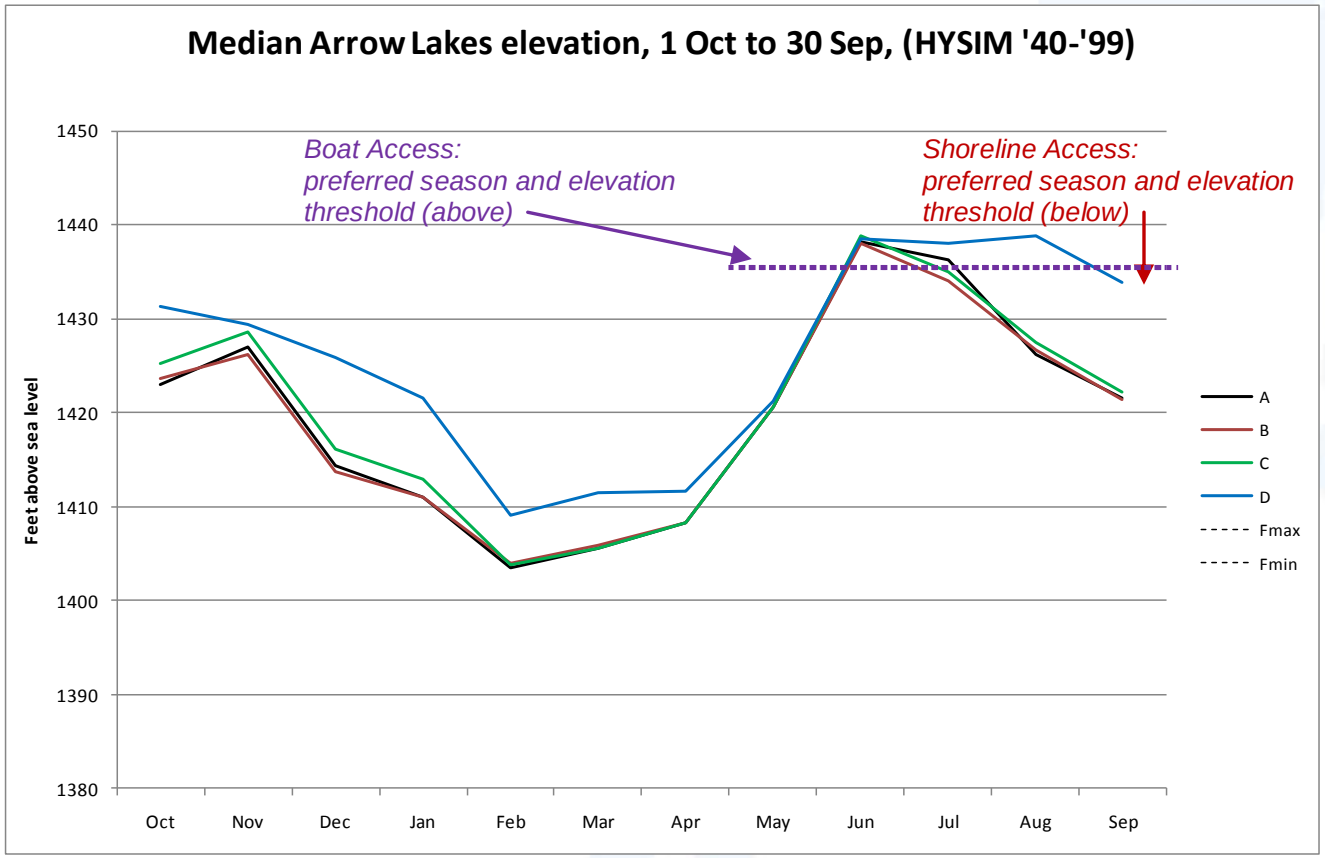
Figure 2: Culture & Heritage – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	113	94	119	171
90th	253	243	257	264
Mean	205	206	213	233
Med	208	208	214	239
10th	161	160	167	188
Min	113	94	119	171



Mid Columbia River – Recreation

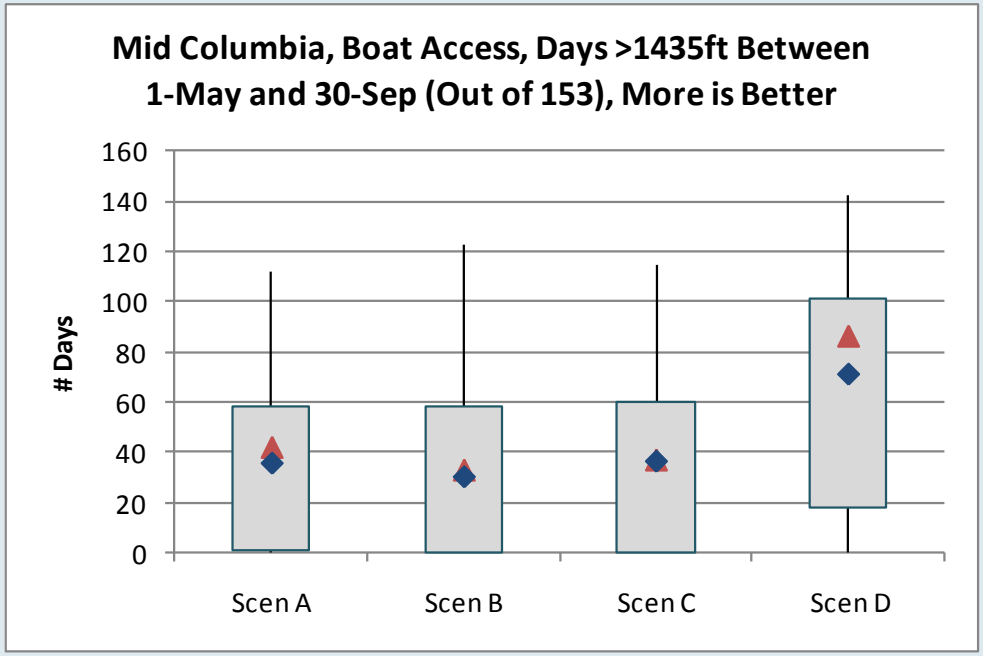
Area	Measure	Dates	Critical Elevation Zone	MSIC
Arrow Lakes Reservoir	Boat Access Days	01 May to 30 Sept	# days at or above 1435 ft	7 days
	Shoreline Access Days	01 May to 30 Sept	# days below 1435 ft	7 days



Mid Columbia River – Boat Access

Figure 2 a: Boat Access Days – HYSIM Results for all NTS scenarios

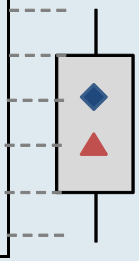
	Scen A	Scen B	Scen C	Scen D
Max	112	123	115	142
90th	58	58	60	101
Mean	36	30	36	71
Med	42	33	37	86
10th	1	0	0	18
Min	0	0	0	0

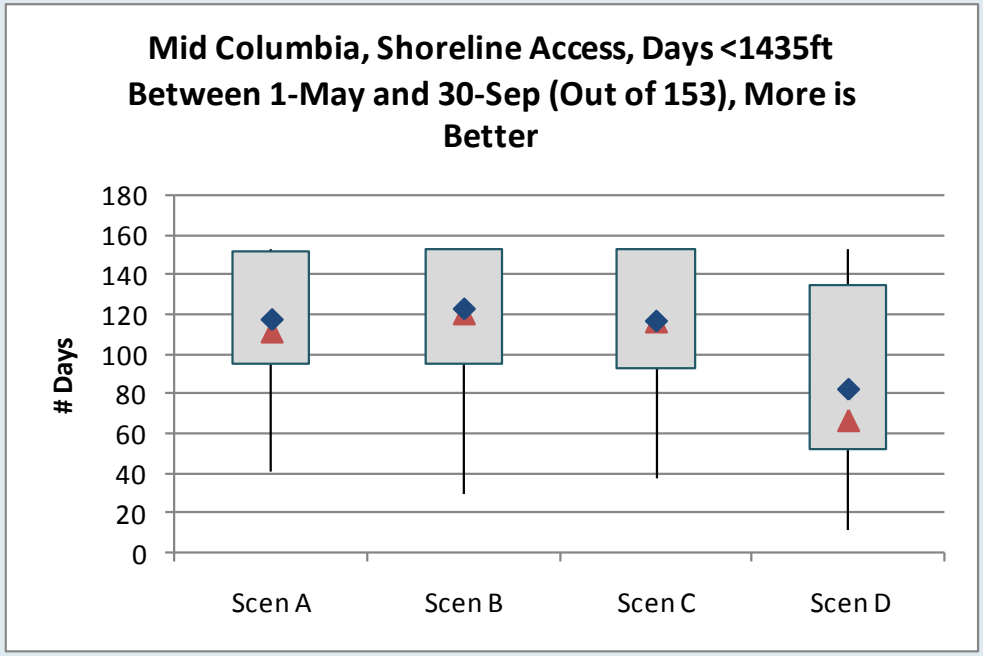


Mid Columbia River – Shoreline Access

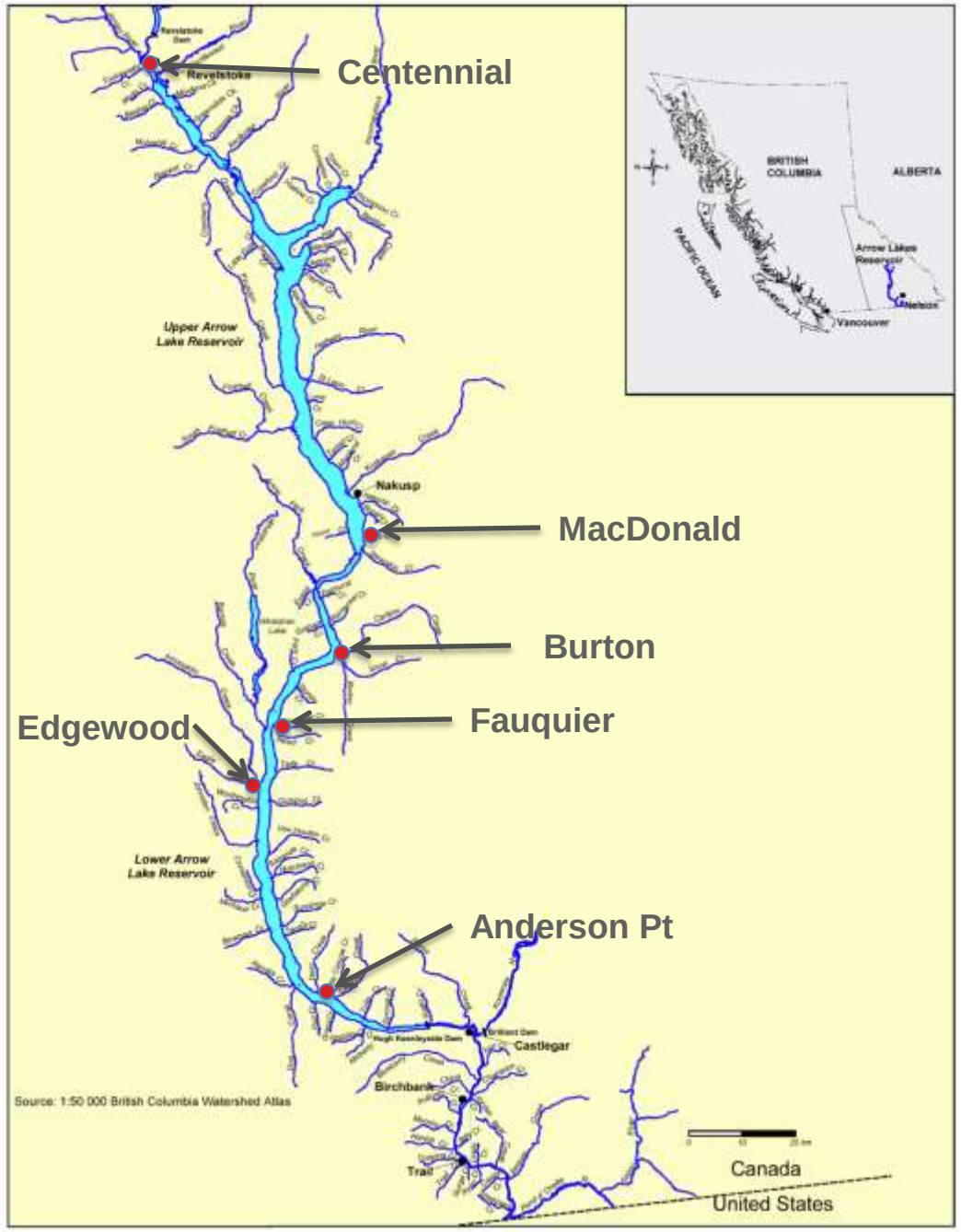
Figure 2 b: Shoreline Access Days – HYSIM Results for all NTSA scenarios

	Scen A	Scen B	Scen C	Scen D
Max	153	153	153	153
90th	152	153	153	135
Mean	117	123	117	82
Med	111	120	116	67
10th	95	95	93	52
Min	41	30	38	11



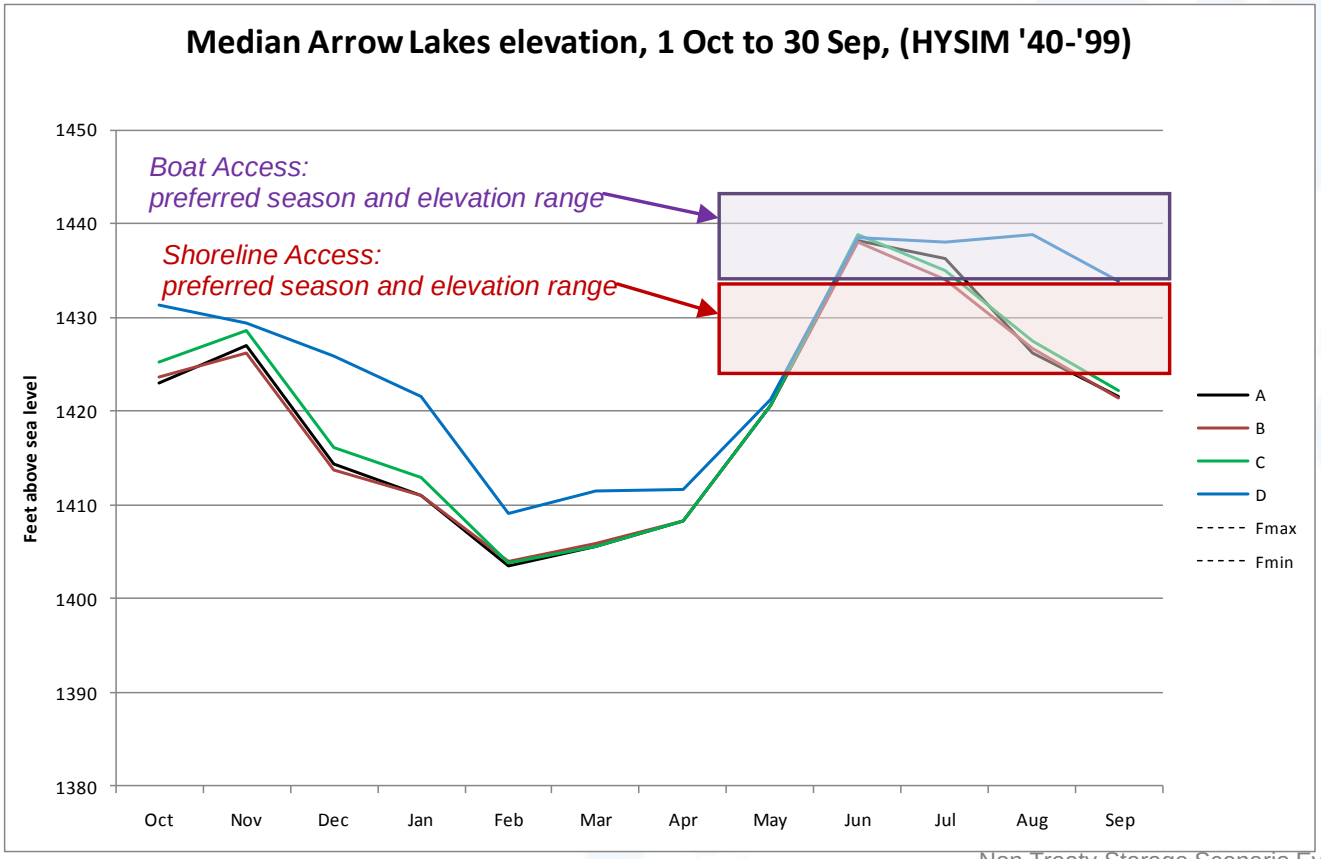


Arrow Lakes Reservoir

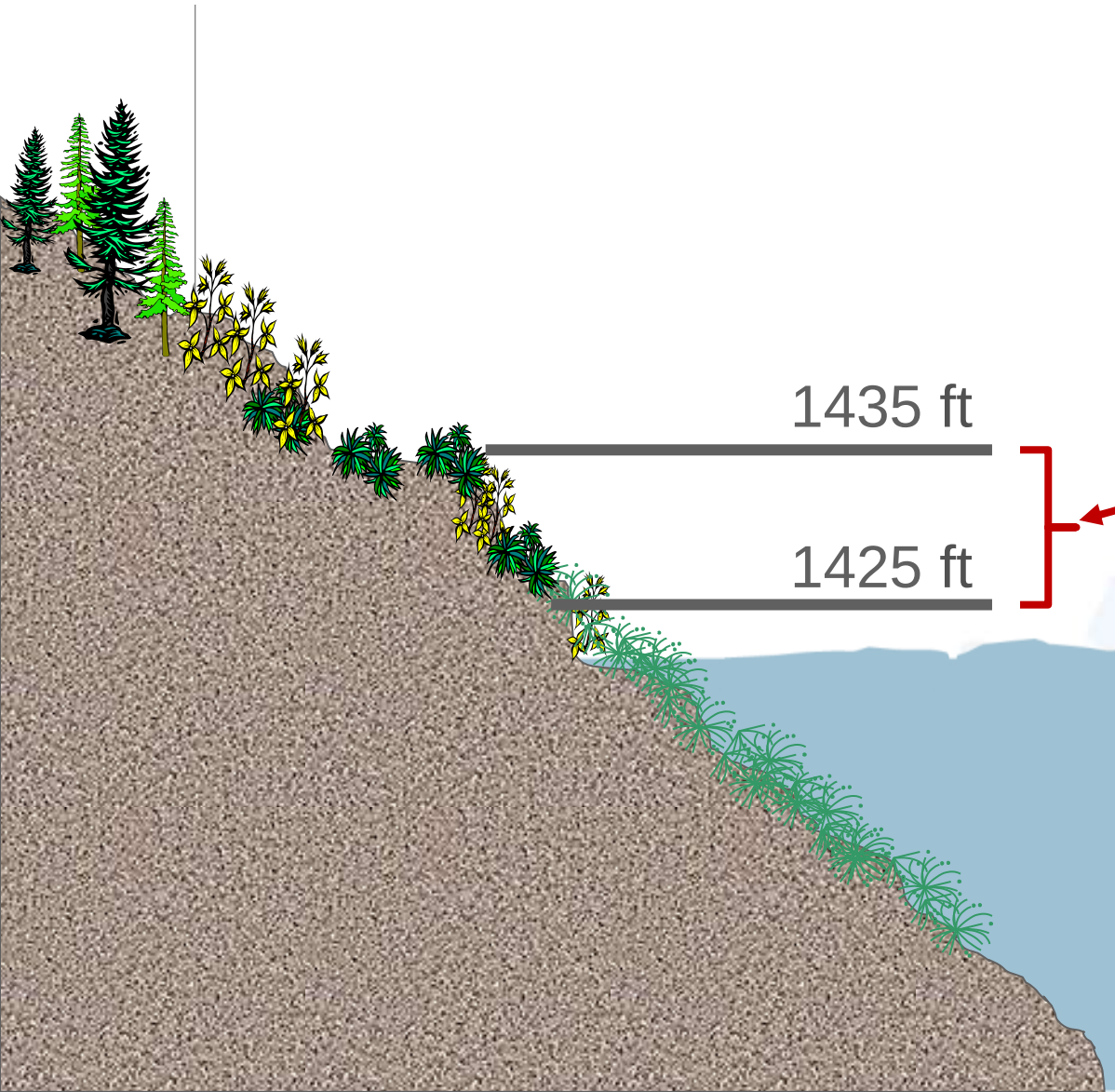


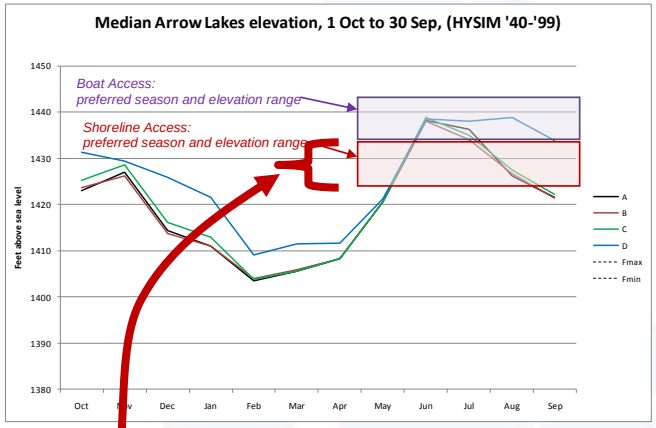
Arrow Lakes Reservoir – Recreation

Area	Measure	Dates	Critical Elevation Zone	MSIC
Arrow Lakes Reservoir	Boat Access Days	01 May to 30 Sept	# days between 1435 – 1444 ft	7 days
	Shoreline Access Days	01 May to 30 Sept	# days between 1425 – 1435 ft	7 days

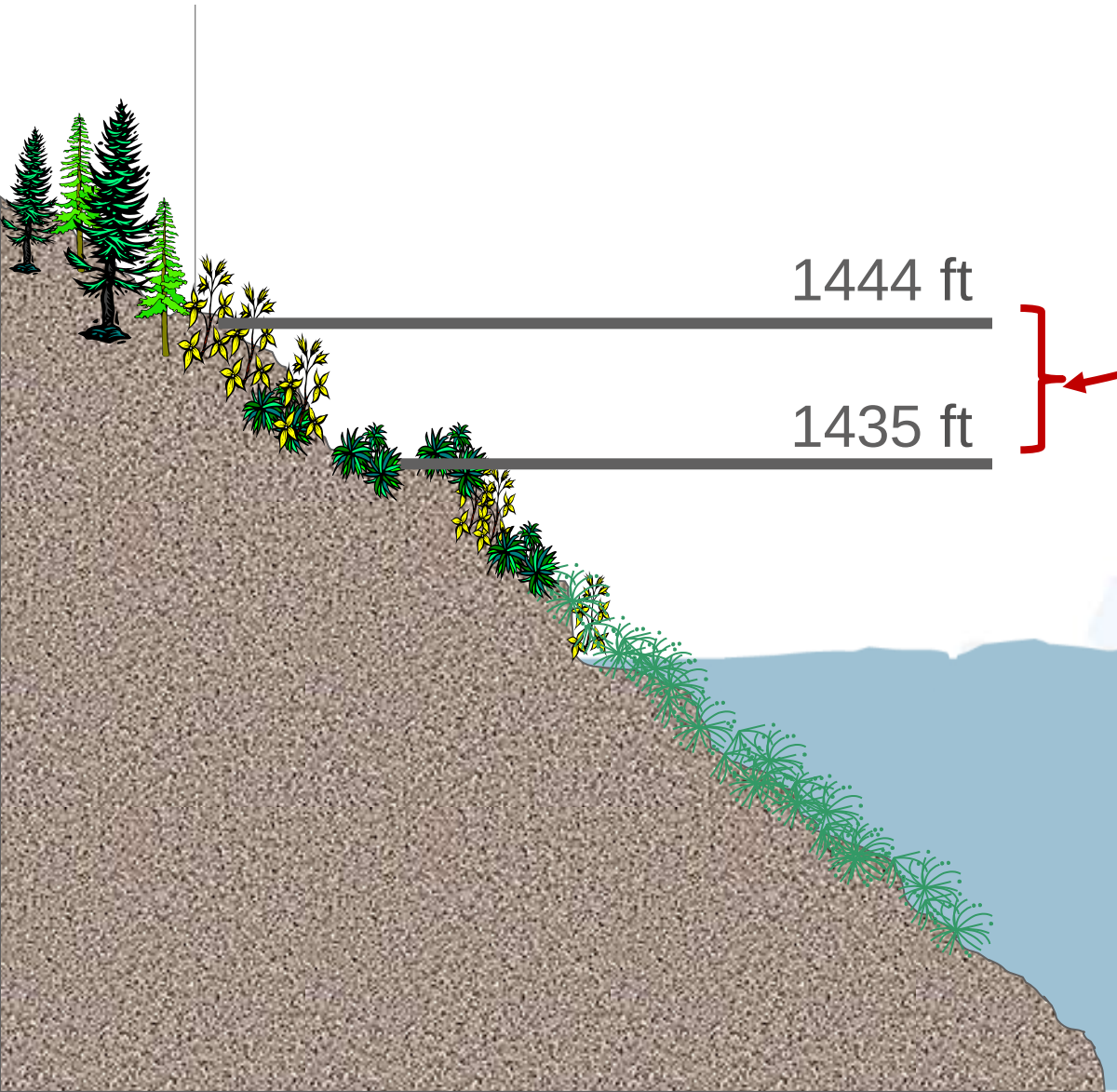


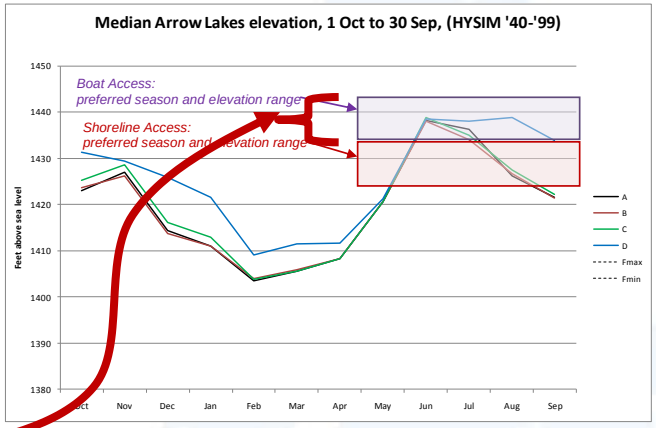
Kinbasket Reservoir – Shoreline Access Days





Kinbasket Reservoir – Boat Access Days

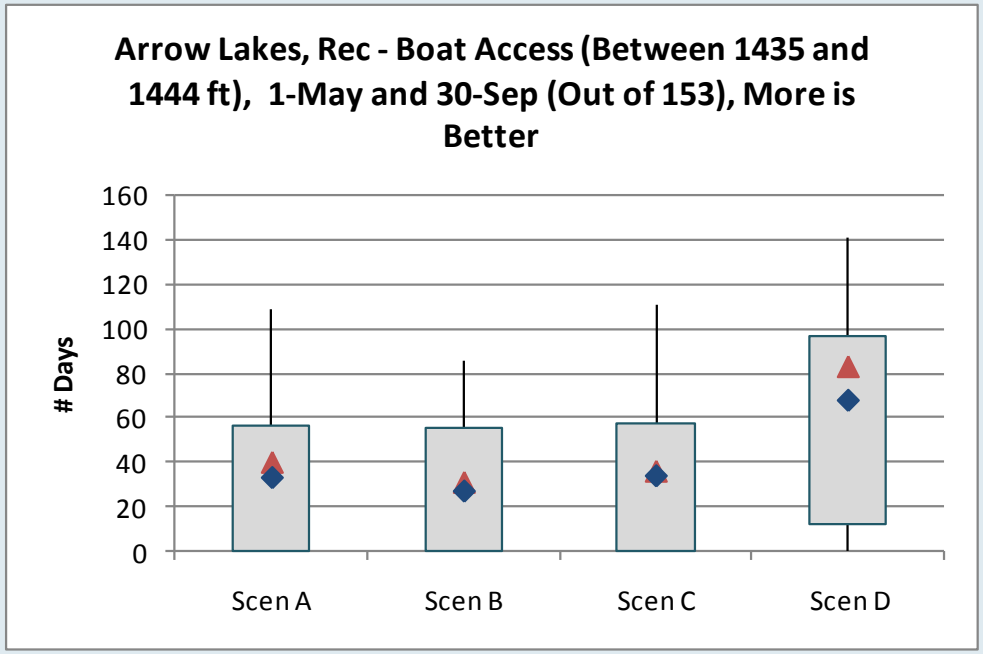




Arrow Lakes Reservoir – Boat Access

Figure 2 a: Boat Access Days – HYSIM Results for all NTS scenarios

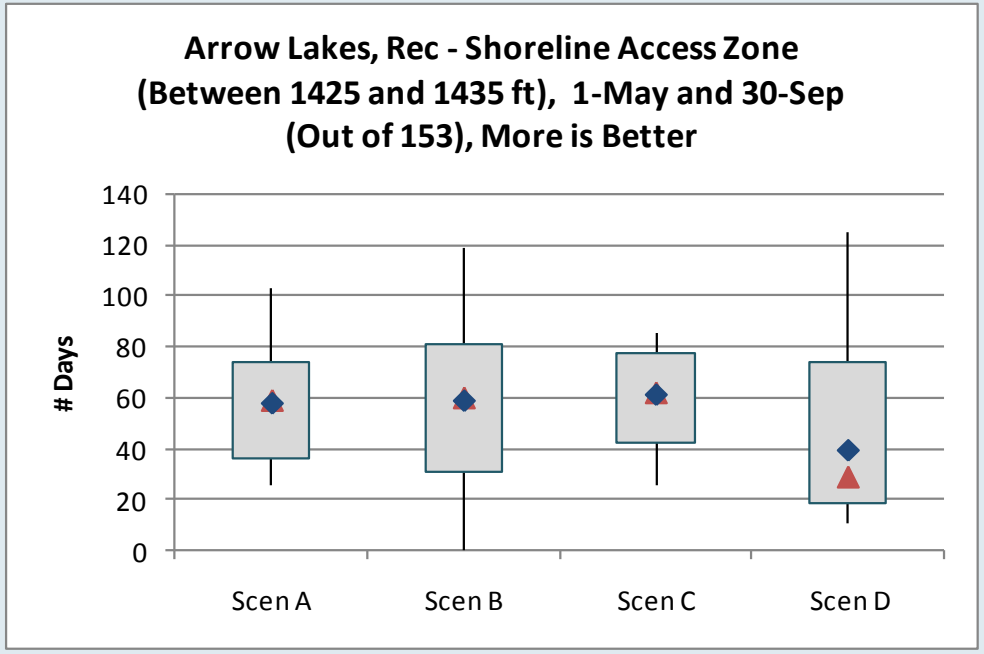
	Scen A	Scen B	Scen C	Scen D
Max	109	86	111	141
90th	56	55	57	97
Mean	33	27	34	68
Med	40	31	36	83
10th	0	0	0	12
Min	0	0	0	0



Arrow Lakes Reservoir – Shoreline Access

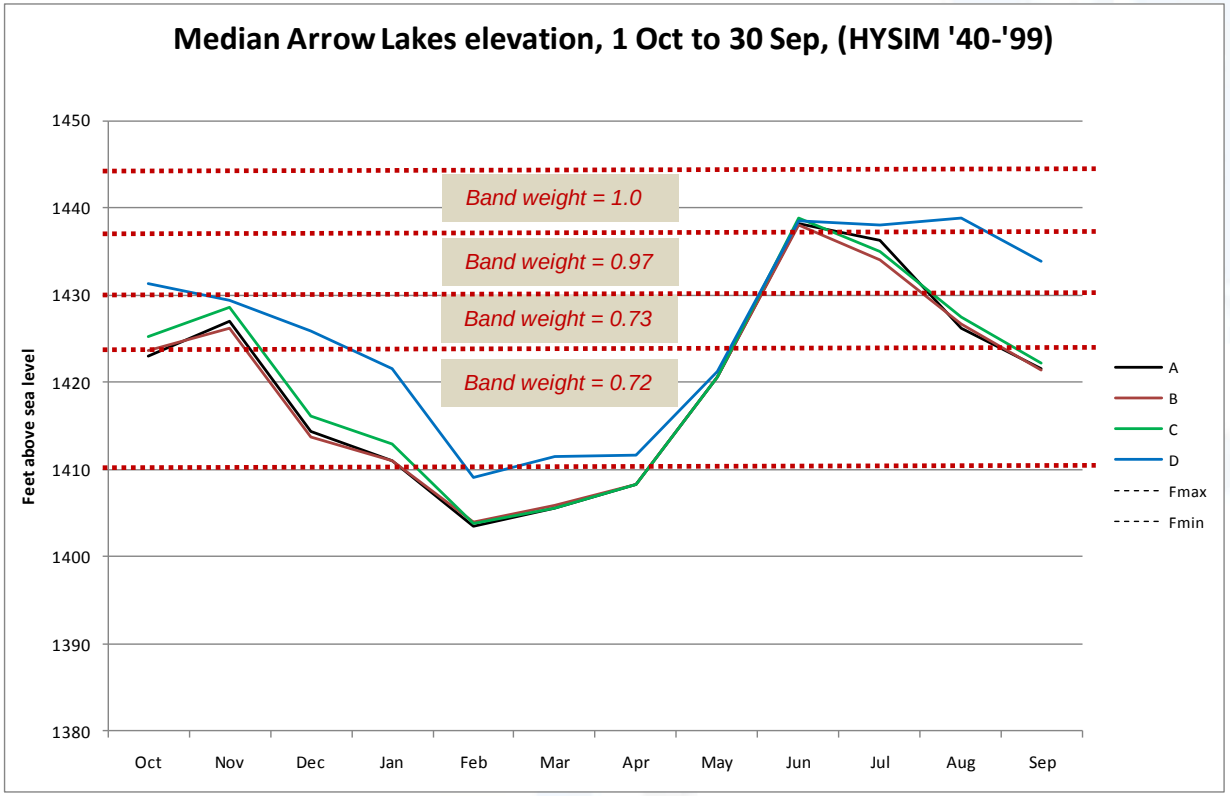
Figure 2 b: Shoreline Access Days – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	103	119	85	125
90th	74	81	78	74
Mean	58	59	61	39
Med	59	60	62	29
10th	36	31	42	19
Min	26	0	26	11



Arrow Lakes Reservoir – Heritage

	Elevation Range (ft)			
	1410<band<1424	1424<band<1430	1430<band<1437	1437<band<1444
Total sites within elevation band	48	49	65	67
Proportion of sites within band	21.0%	21.4%	28.4%	29.3%
Relative day weight	0.72	0.73	0.97	1

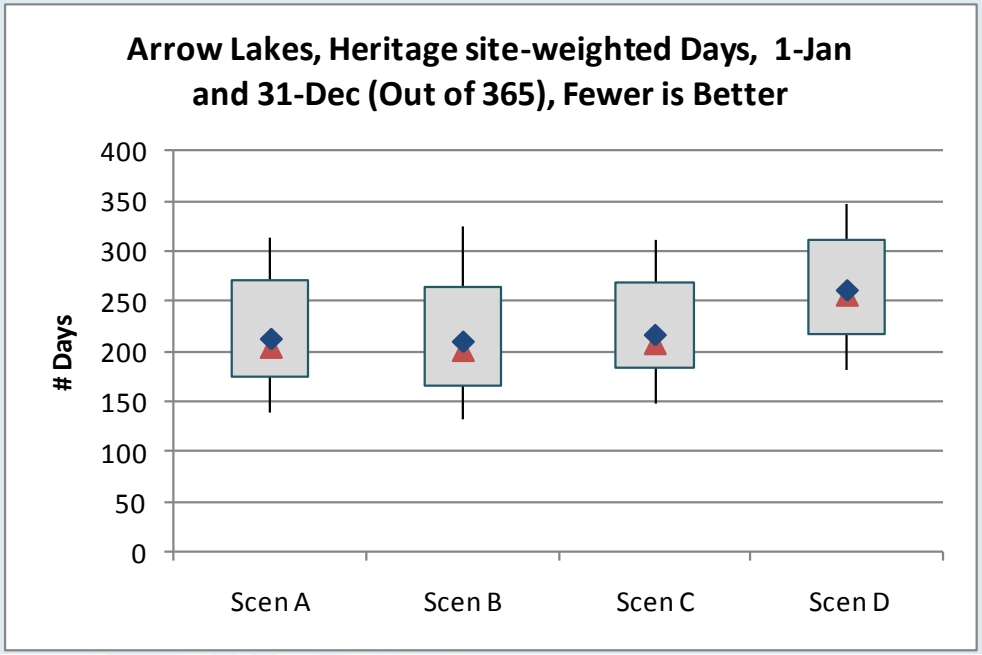


Arrow Lakes Reservoir – Heritage

RESULTS

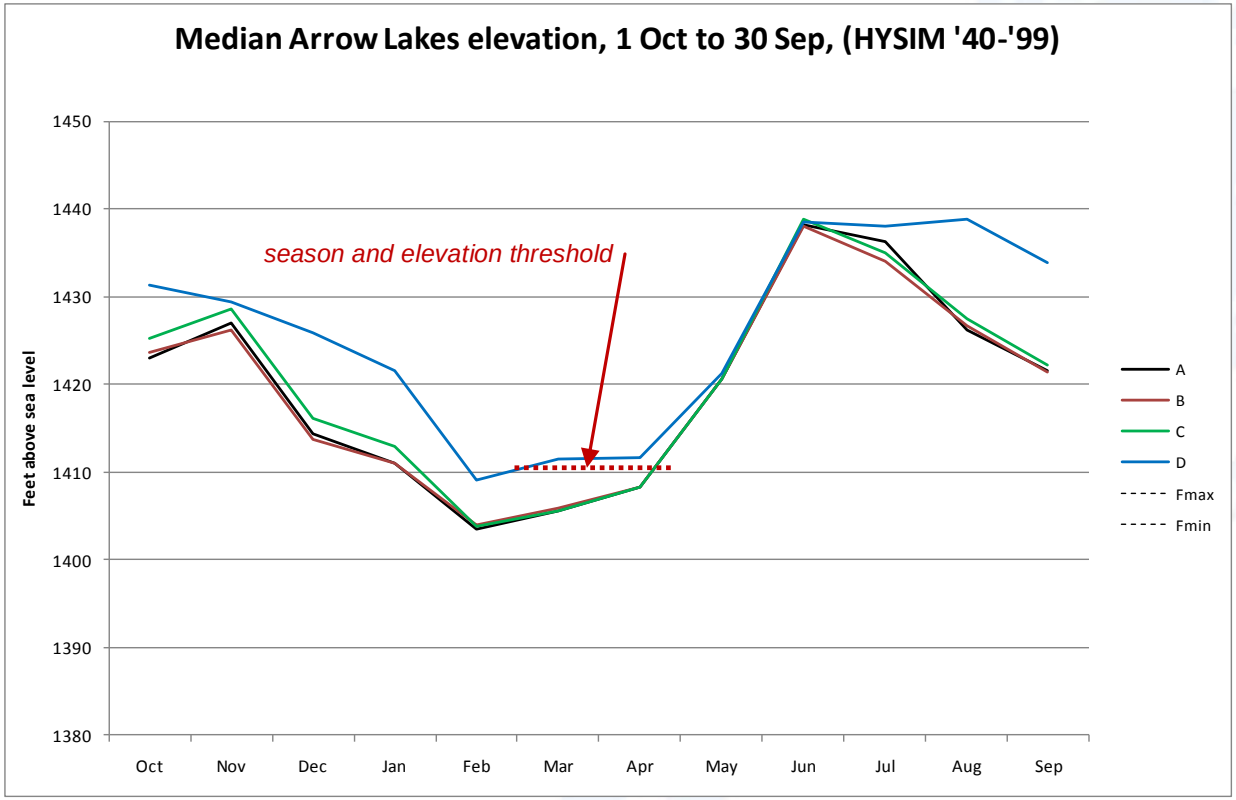
Figure2: Culture & Heritage – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	313	324	311	348
90th	270	264	269	312
Mean	212	209	216	262
Med	205	202	209	257
10th	176	166	184	218
Min	138	132	148	182



Arrow Lakes Reservoir – Dust

Objective / Location	Performance Measure	Units	Description
Dust Control/Arrow Reservoir	Dust potential days	# days elevation is below 1410 ft between 1 March and 30 April	Sum of # days per year that the reservoir water level is below 1410 ft when dust generation potential is highest in the lower elevations.

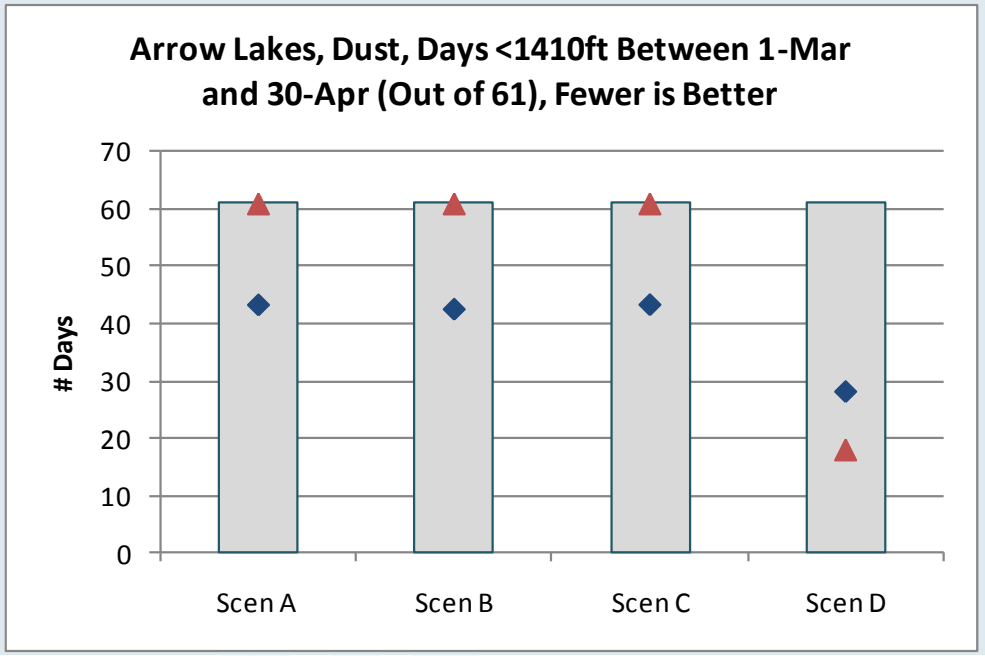


Arrow Lakes Reservoir – Dust

RESULTS

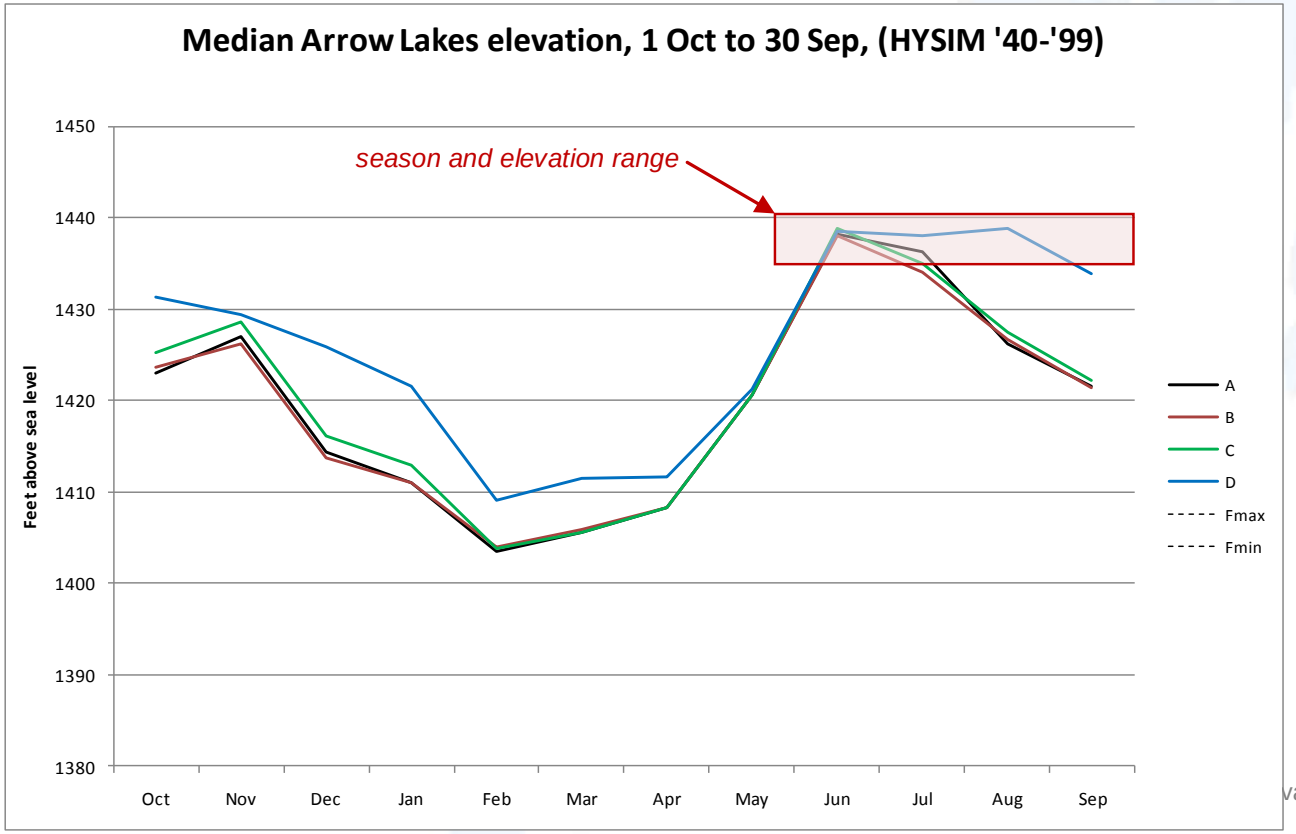
Figure 2: Dust Control – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	61	61	61	61
90th	61	61	61	61
Mean	43	42	43	28
Med	61	61	61	18
10th	0	0	0	0
Min	0	0	0	0



Arrow Lakes Reservoir – Soft Constraint - REC

Objective / Location	Performance Measure	Units	Description	MSIC
Recreation Soft Constraint/Arrow Reservoir	Recreation access	# days elevation is between 1435 and 1440 ft from 24 May to 30 September	Sum of # days the reservoir water level is within the preferred elevation range over the recreation season	7 days per year

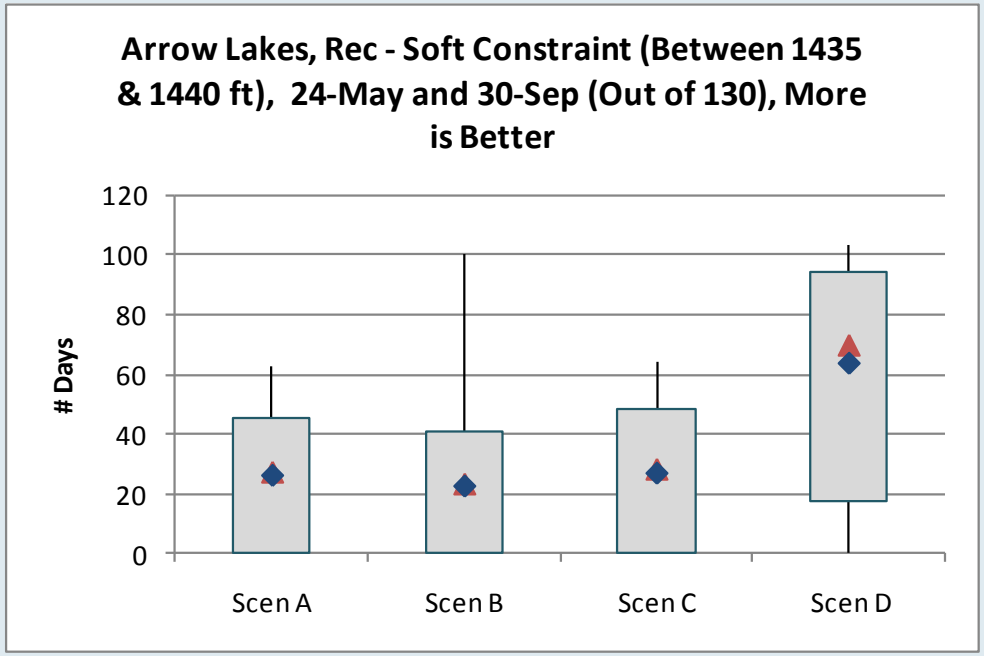


Arrow Lakes Reservoir – Soft Constraint - REC

RESULTS

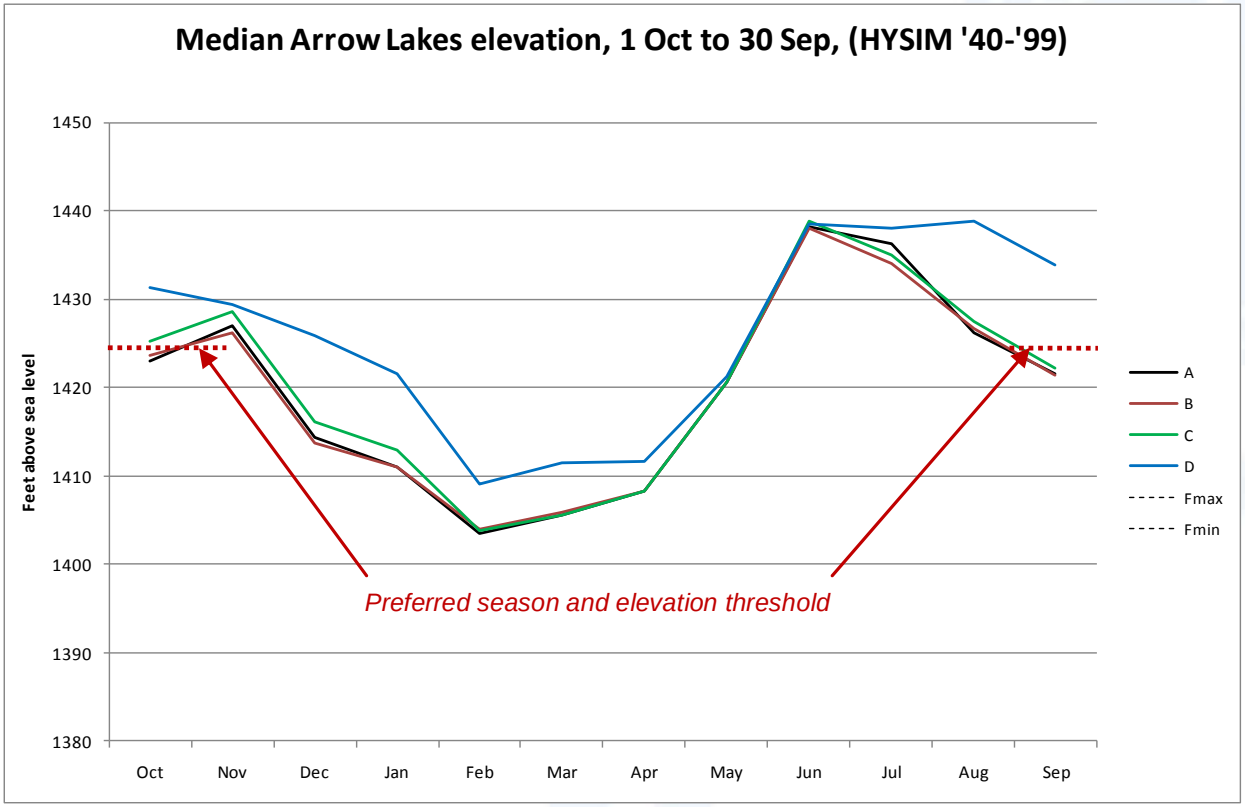
Recreation – HYSIM Results for all NTS scenarios:

	Scen A	Scen B	Scen C	Scen D
Max	63	100	64	103
90th	45	41	48	94
Mean	26	22	27	63
Med	27	23	28	70
10th	0	0	0	17
Min	0	0	0	0



Arrow Lakes Reservoir – Soft Constraint - FISH

Objective / Location	Performance Measure	Units	Description
Fish Soft Constraint/Arrow Reservoir	Tributary Access	# days elevation above 1424 ft between 25 August and 15 November	Sum of # days over the kokanee and bull trout spawning periods that the reservoir water level is at or above 1424 ft.

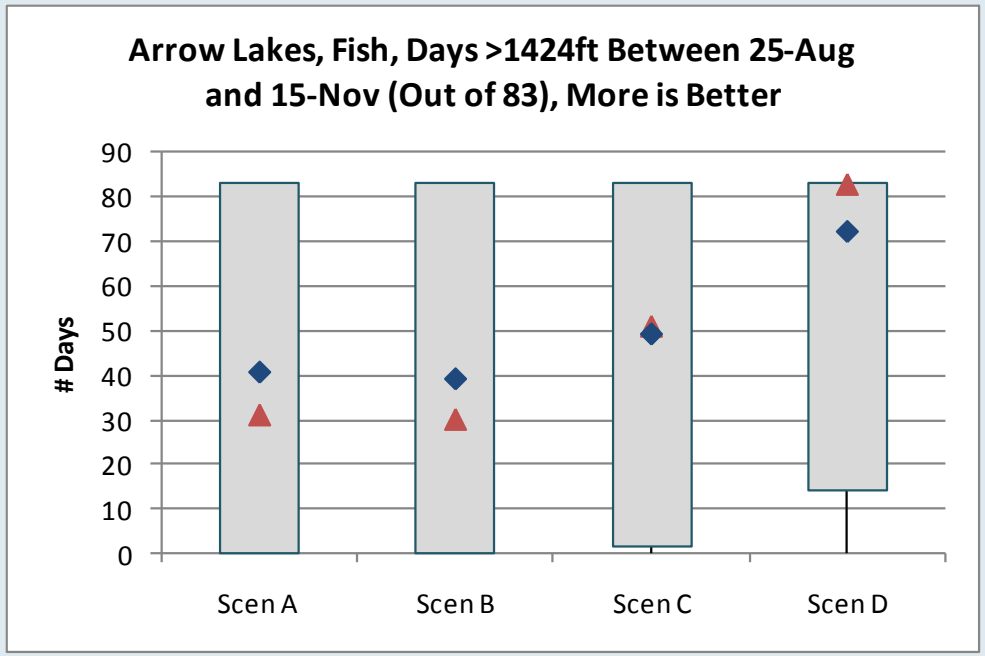


Arrow Lakes Reservoir – Soft Constraint - FISH

RESULTS

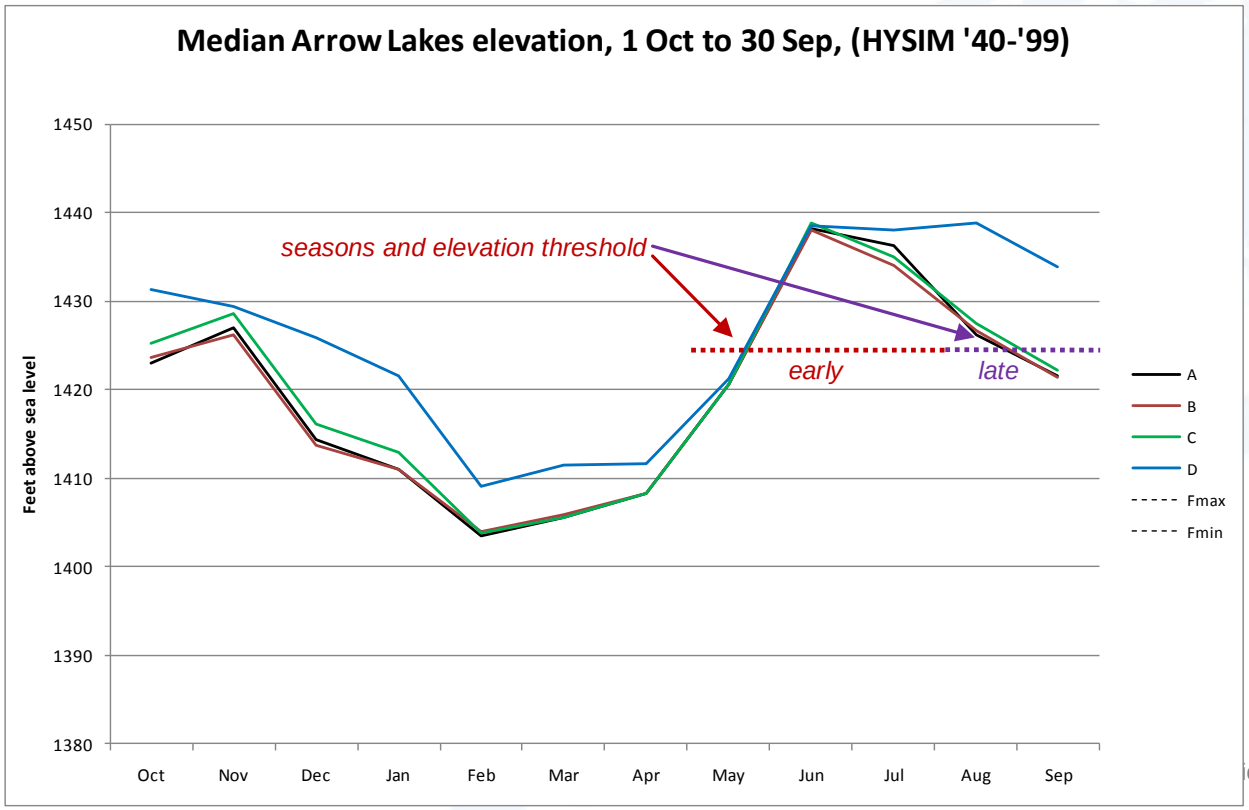
Figure 2: Tributary Access – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	83	83	83	83
90th	83	83	83	83
Mean	41	39	49	72
Med	31	30	51	83
10th	0	0	2	14
Min	0	0	0	0



Arrow Lakes Reservoir – Soft Constraint - VEG

Objective / Location	Performance Measure	Units	Description
Vegetation Soft Constraint/Arrow Reservoir	Vegetation Establishment & Survival	# days elevation at and above 1424 ft between 1 May and 31 July, and 1 August and 30 September	Sum of # days over the reservoir water level is at and above 1424 ft over the early and latter part of the growing season

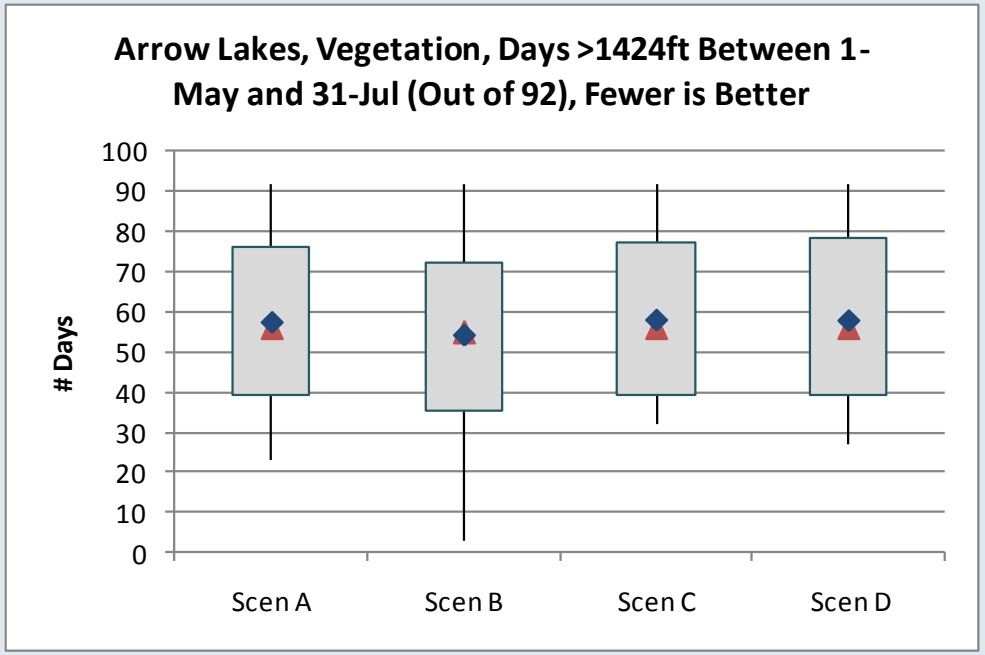


Arrow Lakes Reservoir – Soft Constraint - VEG

RESULTS

Figure 2 a: Vegetation: Early Growing Season – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	92	92	92	92
90th	76	72	77	78
Mean	57	54	58	58
Med	56	55	56	56
10th	39	35	39	39
Min	23	3	32	27

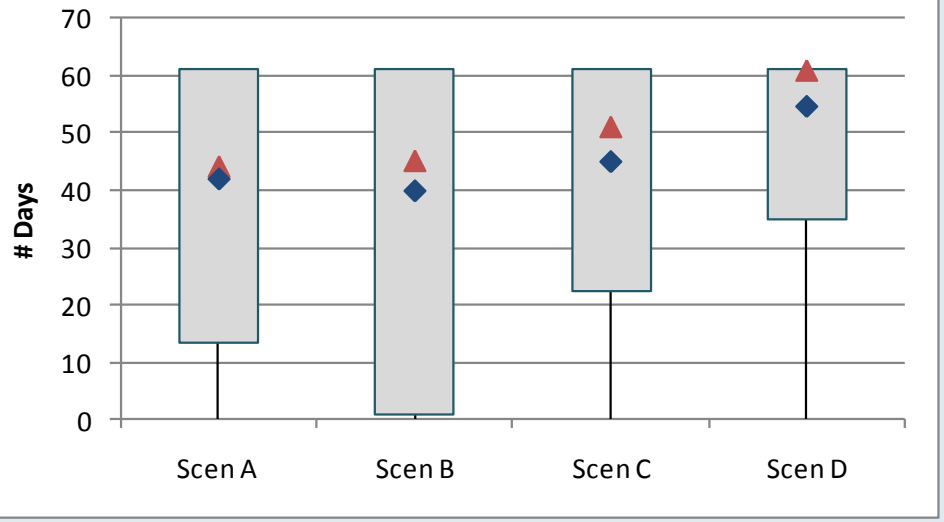


Arrow Lakes Reservoir – Soft Constraint - VEG

RESULTS

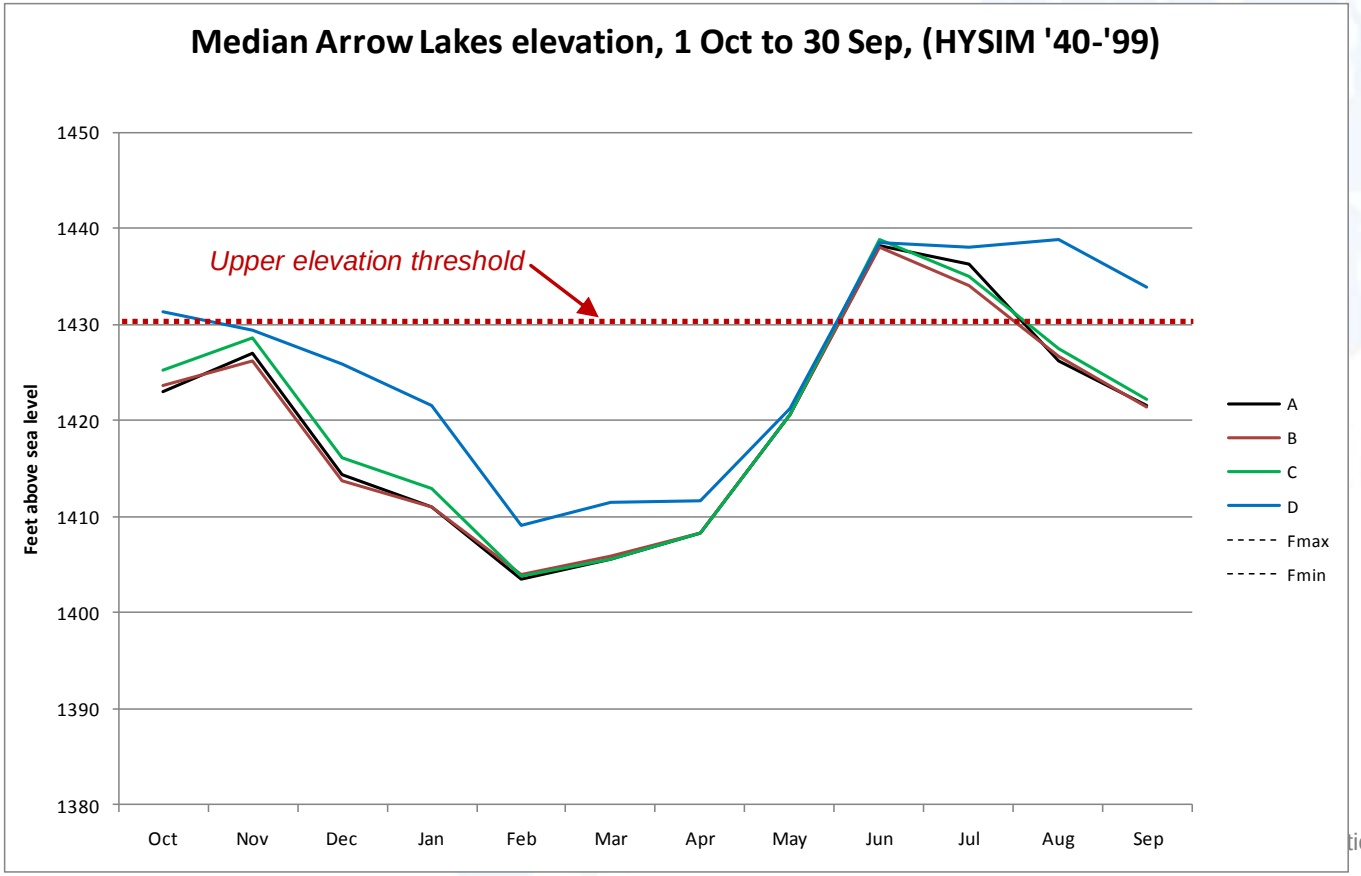
Figure 2 b: Vegetation: Latter Growing Season – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	61	61	61	61
90th	61	61	61	61
Mean	42	40	45	55
Med	44	45	51	61
10th	13	1	22	35
Min	0	0	0	0



Arrow Lakes Reservoir – Soft Constraint - HERITAGE

Objective / Location	Performance Measure	Units	Description	MSIC
Culture & Heritage Soft Constraint/ Arrow Reservoir	Archaeological site protection	# days elevation is at or below 1430 ft over year	Sum of # days per year that the reservoir water level is at or below 1430 ft	7 days per year

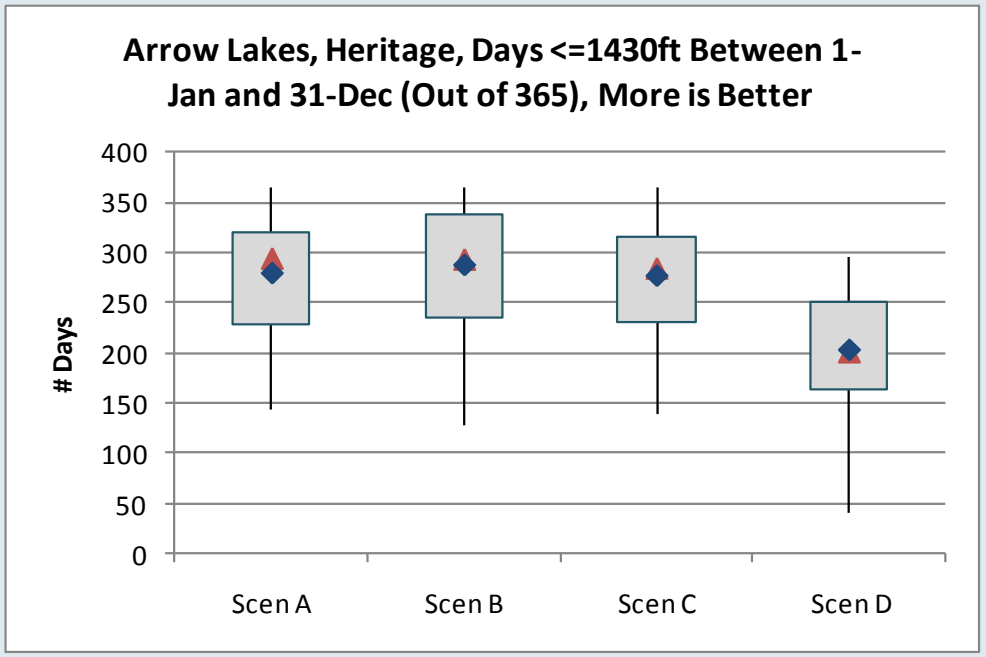


Arrow Lakes Reservoir – Soft Constraint - HERITAGE

RESULTS

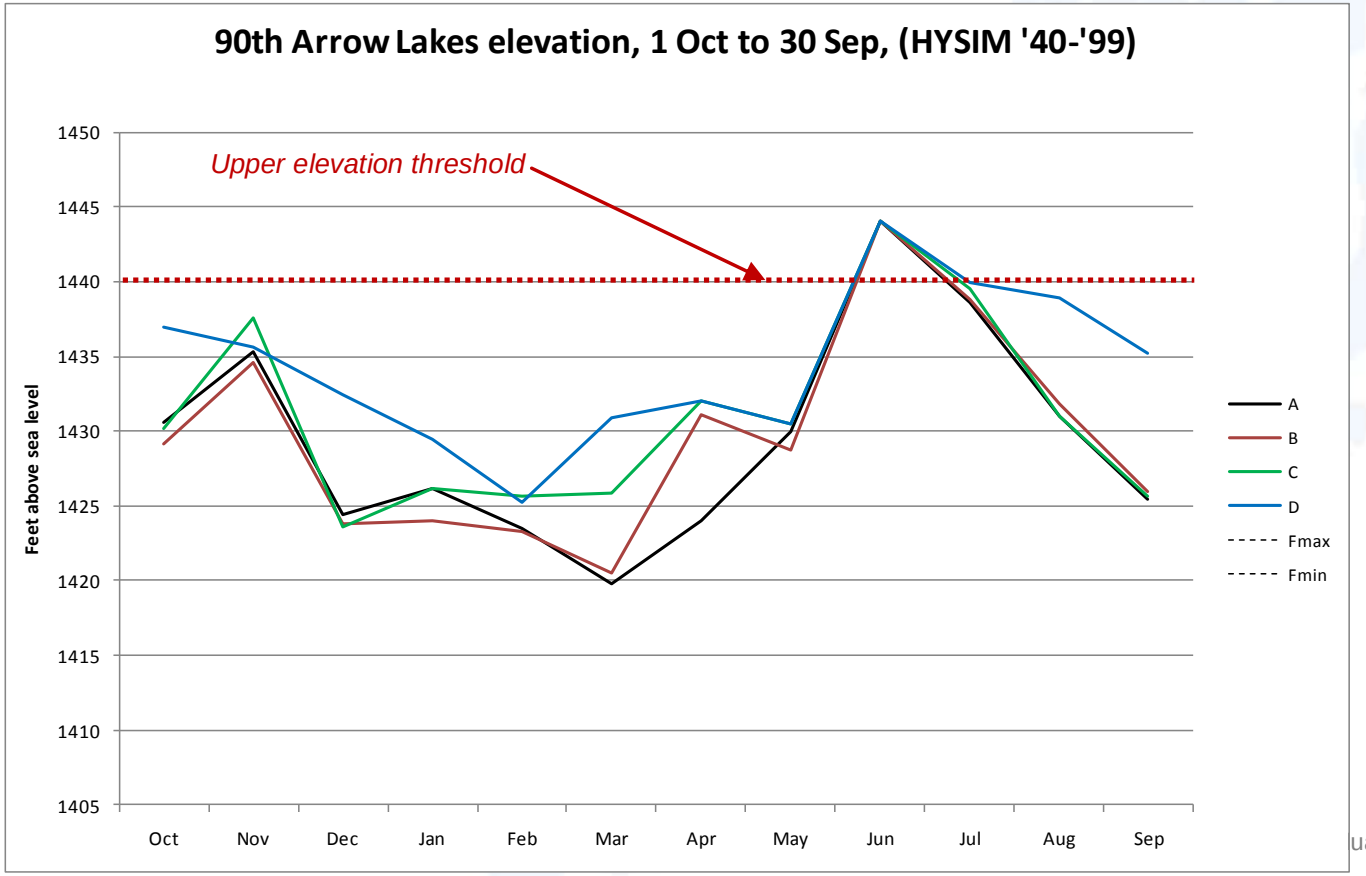
Figure 2: Culture & Heritage – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	365	365	365	295
90th	321	338	317	251
Mean	280	288	277	202
Med	294	293	284	200
10th	228	235	230	164
Min	144	128	139	40



Arrow Lakes Reservoir – Soft Constraint - EROSION

Objective / Location	Performance Measure	Units	Description	MSIC
Erosion Soft Constraint/Arrow Reservoir	Erosion Control	# days elevation is at or above 1440 ft over the year	Sum of # days per year that the reservoir water level is at or above 1440 ft	7 days per year

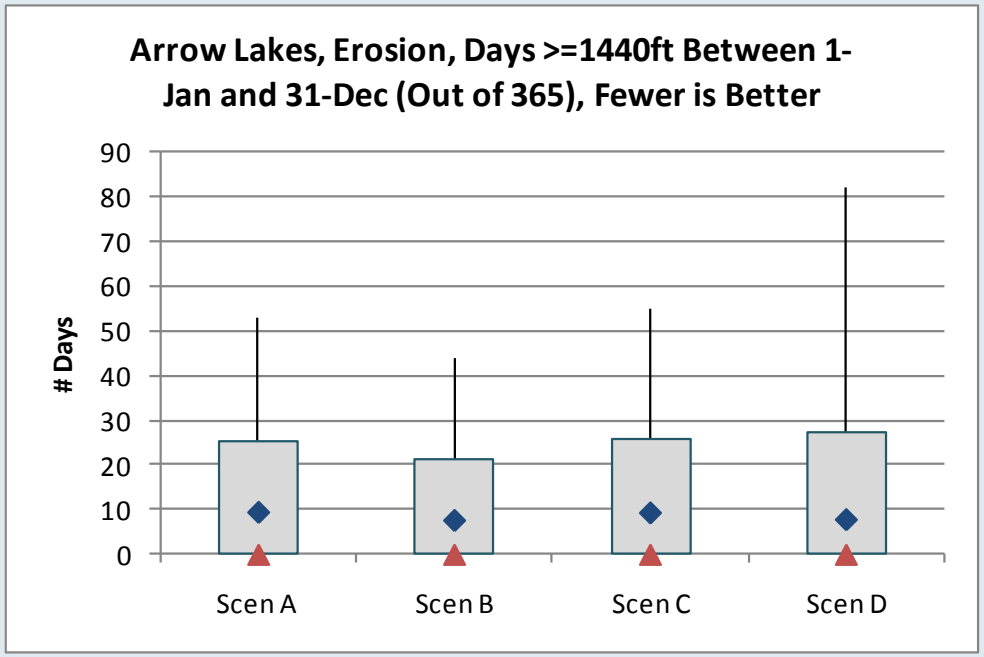


Arrow Lakes Reservoir – Soft Constraint - EROSION

RESULTS

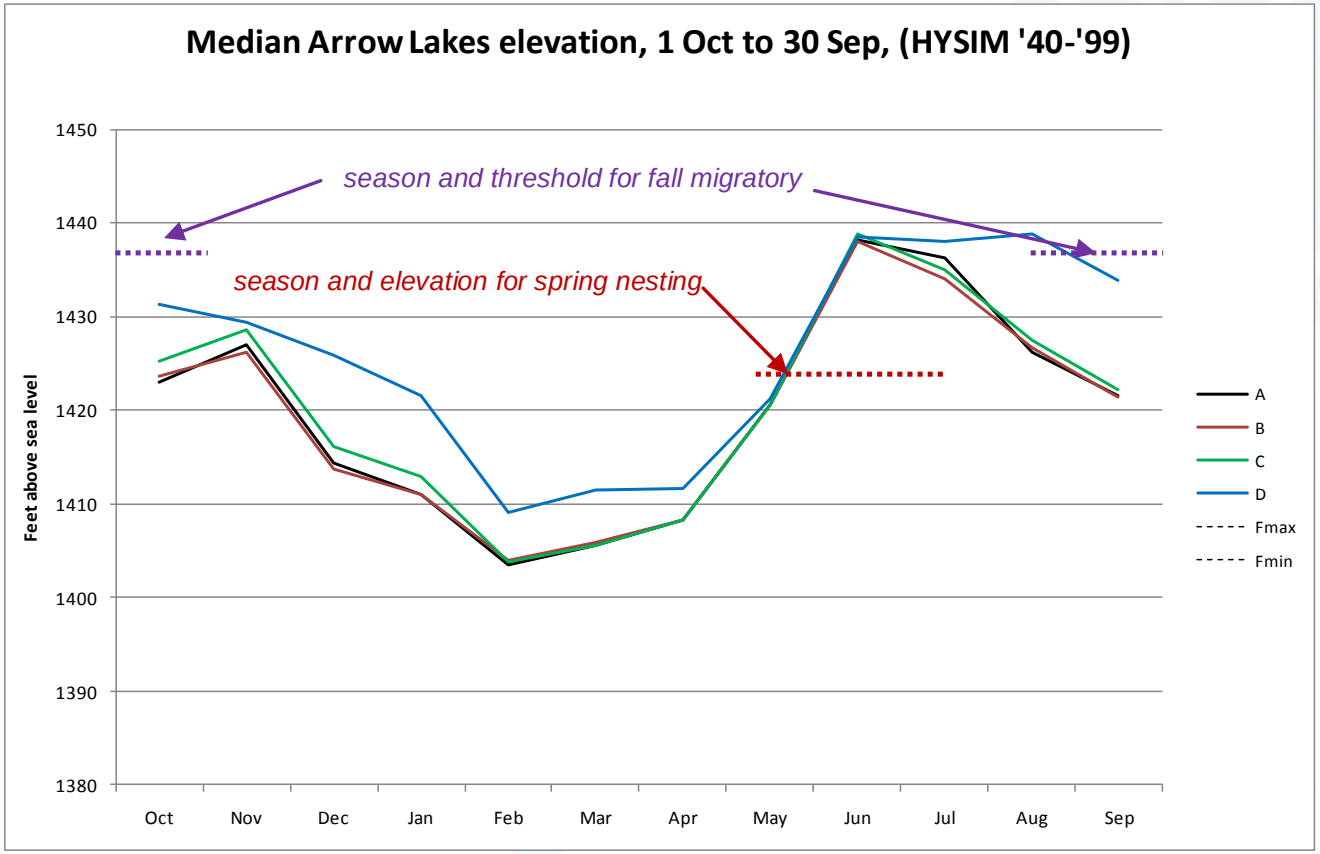
Figure 2: Erosion – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	53	44	55	82
90th	25	21	26	27
Mean	9	7	9	8
Med	0	0	0	0
10th	0	0	0	0
Min	0	0	0	0



Arrow Lakes Reservoir – Soft Constraint - WILDLIFE

Objective / Location	Performance Measure	Units	Description
Wildlife Soft Constraint/Arrow Reservoir	Nesting Birds	# days elevation is below 1424 ft between 30 April and 16 July	Sum of # days per year that the reservoir water level is within the defined elevation range over the nesting period
	Fall Migratory Birds	# days elevation is below 1437 ft between 7 August and 31 October	Sum of # days per year that the reservoir water level is within the defined elevation range over the fall migratory period

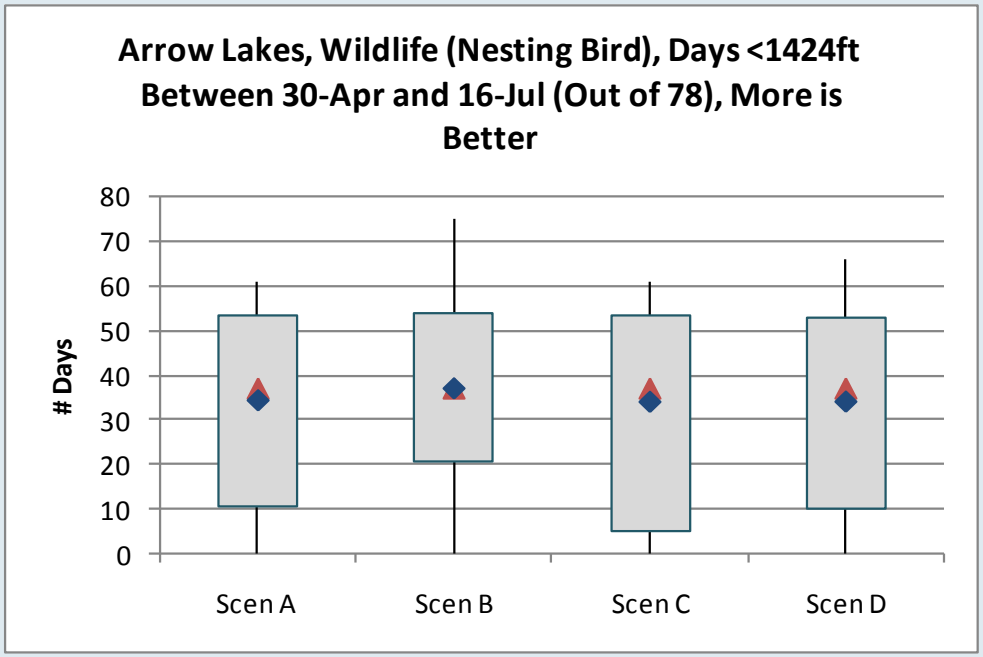


Arrow Lakes Reservoir – Soft Constraint - WILDLIFE

RESULTS

Figure 2 a: Nesting Bird Habitat – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	61	75	61	66
90th	53	54	53	53
Mean	34	37	34	34
Med	37	37	37	37
10th	11	21	5	10
Min	0	0	0	0

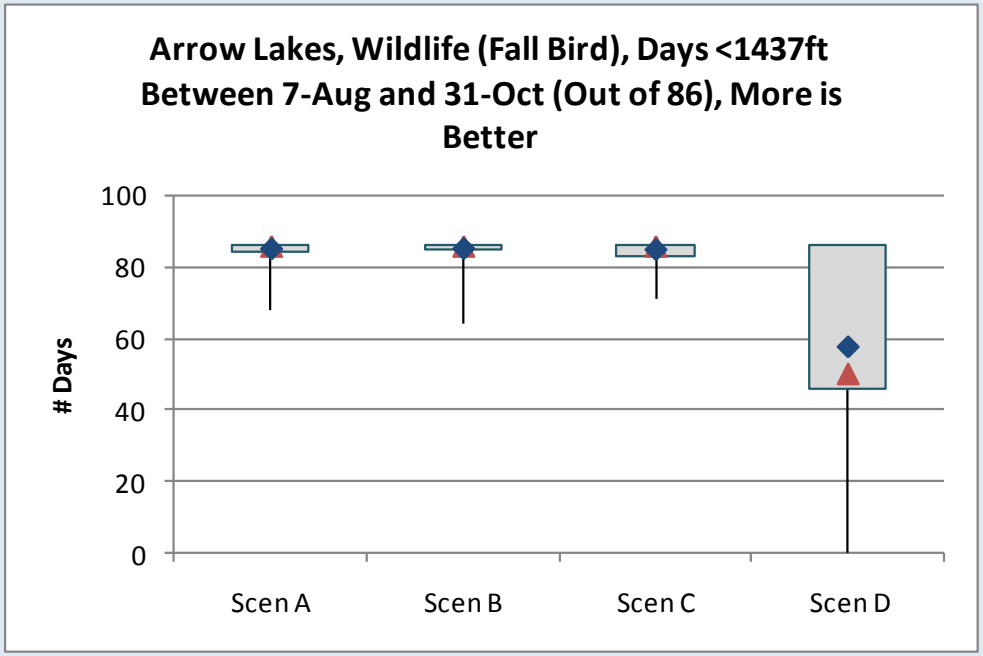


Arrow Lakes Reservoir – Soft Constraint - WILDLIFE

RESULTS

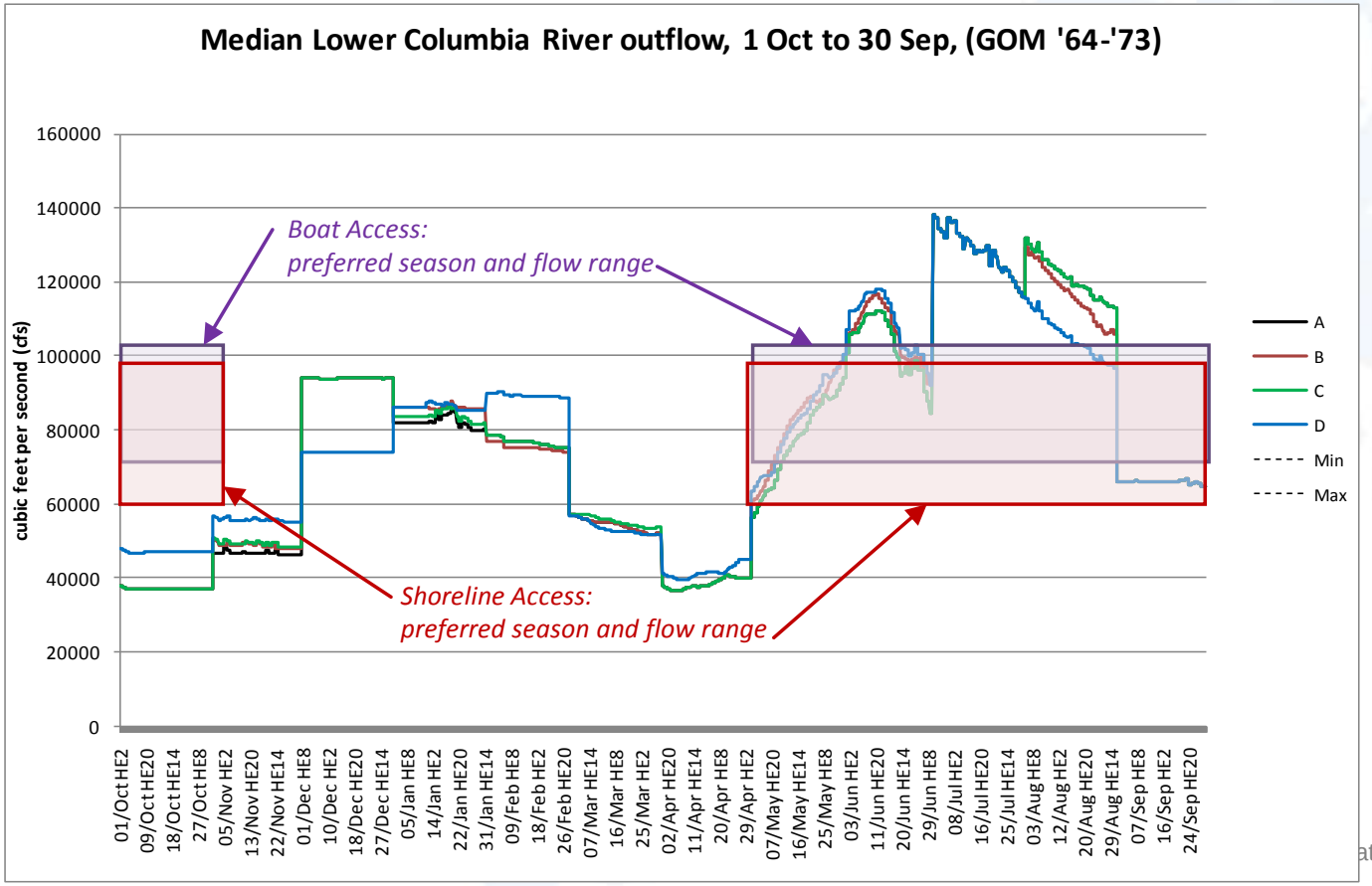
Figure 2 b: Fall Migrating Bird Habitat – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	86	86	86	86
90th	86	86	86	86
Mean	85	85	85	58
Med	86	86	86	50
10th	84	85	83	46
Min	68	64	71	0



Lower Columbia River - Recreation

Area	Measure	Dates	Critical Elevation Zone	MSIC
Lower Columbia River	Boat Access Days	1 May to 30 Oct	# days HLK + BRD flow between 70 902 and 102 823 cfs	7 days
	Shoreline Access Days	1 May to 30 Oct	# days HLK + BRD flow between 60 309 and 99 327 cfs	7 days

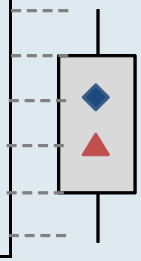


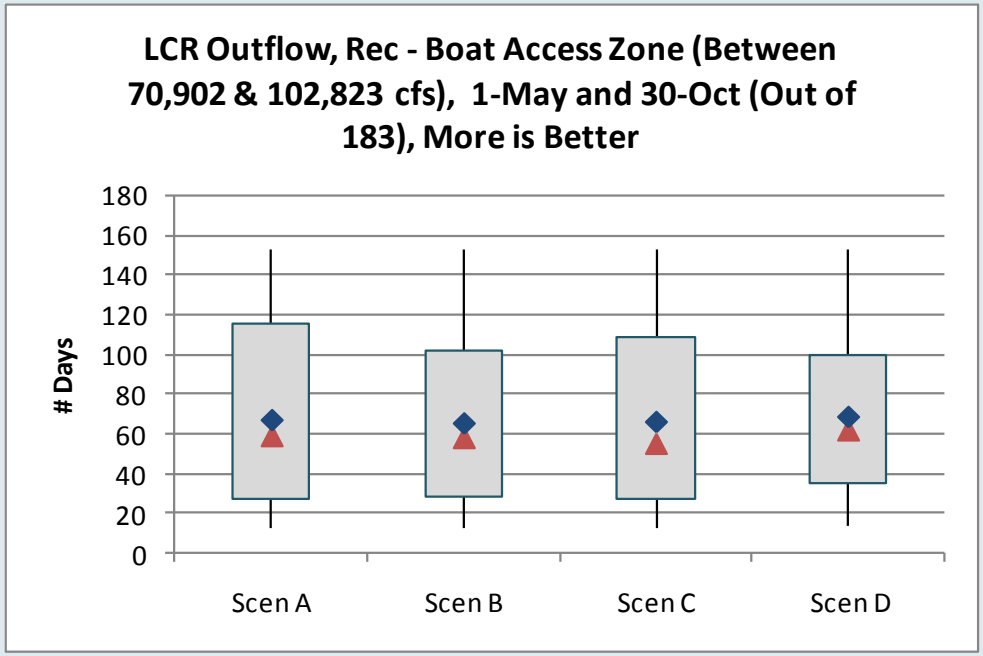
Lower Columbia River - Recreation

RESULTS

Figure 2 a: Boat Access Days – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	153	153	153	153
90th	116	102	108	100
Mean	67	65	66	69
Med	59	58	55	62
10th	28	29	28	36
Min	13	13	13	14



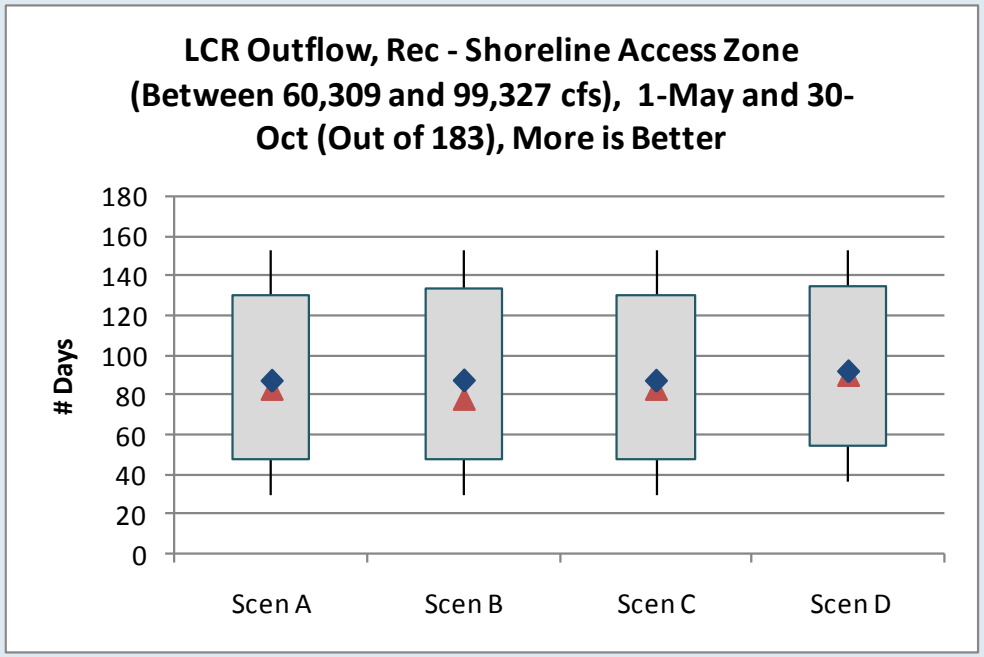


Lower Columbia River - Recreation

RESULTS

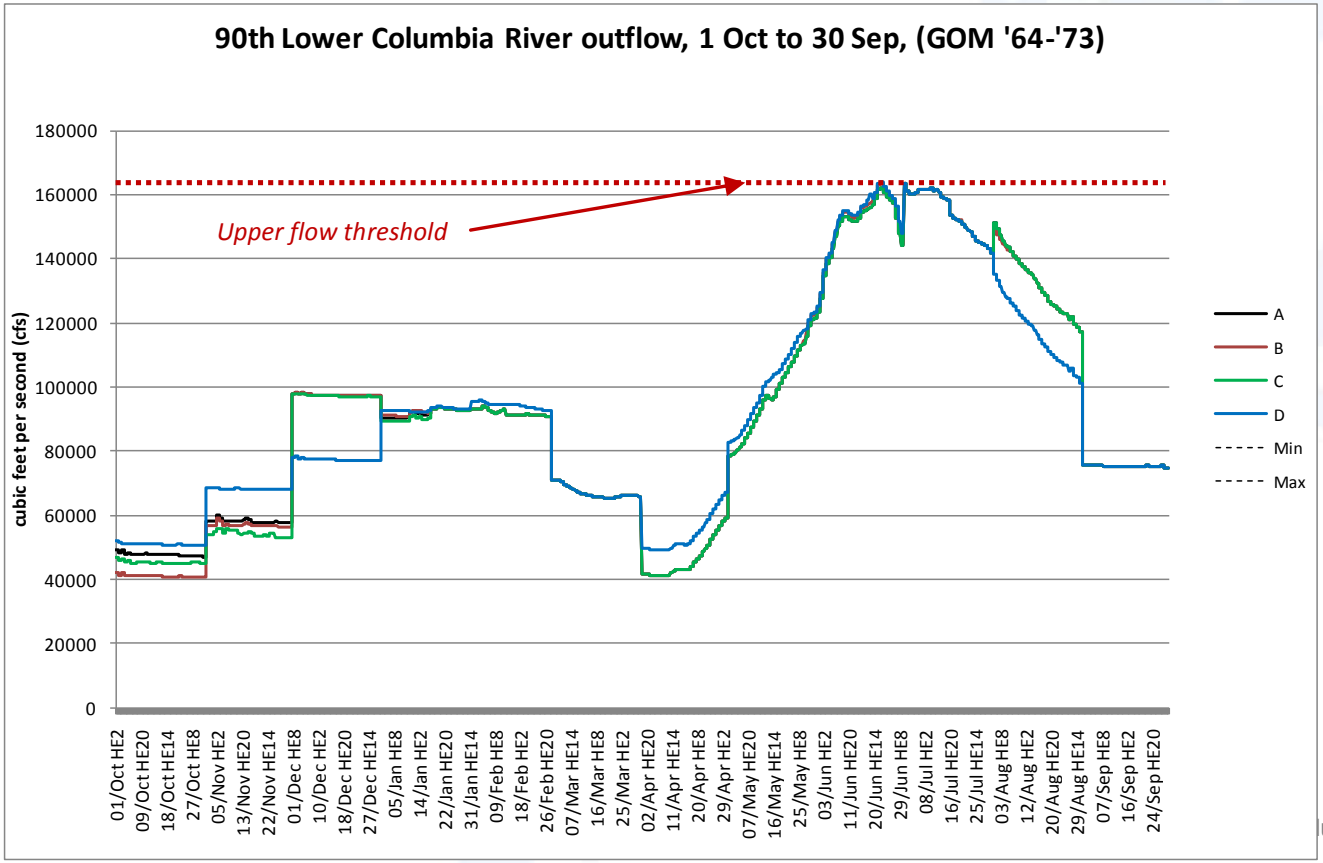
Figure 2 b: Shoreline Access Days – HYSIM Results for all NTS scenarios

	Scen A	Scen B	Scen C	Scen D
Max	153	153	153	153
90th	130	134	130	134
Mean	87	87	87	92
Med	83	78	83	90
10th	48	48	48	54
Min	30	30	30	36



Lower Columbia River - Flooding

Objective / Location	Performance Measure	Units	Description	MSIC
Flood Control: Lower Columbia River	Frequency of Flood Flows	# of potential flood days per year at Genelle (> 165 kcfs)	Frequency with which flows exceed 165 000 cfs (flood threshold at Genelle)	N/A

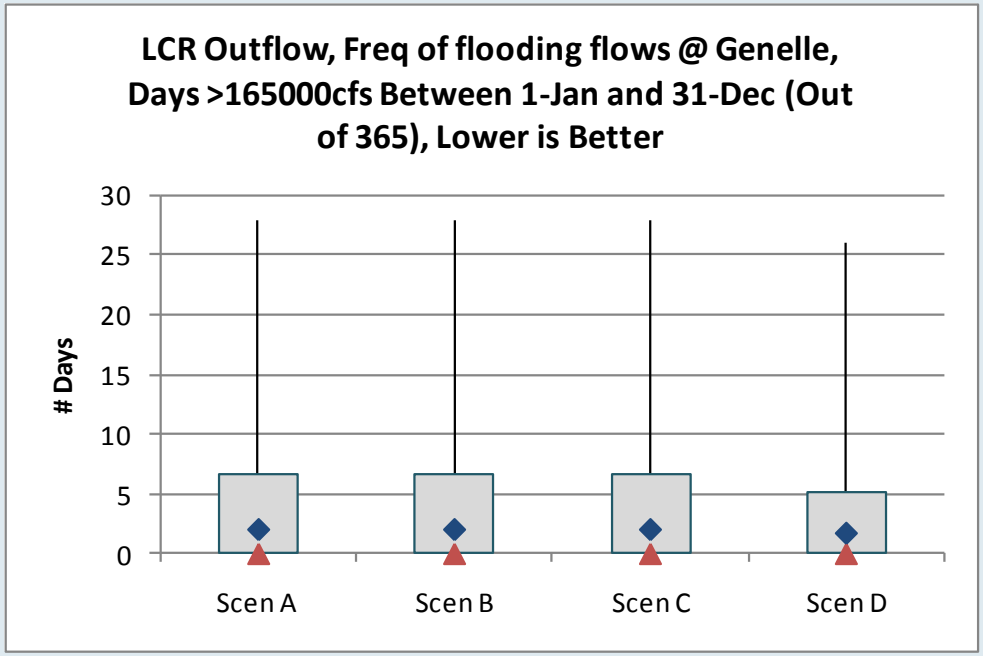


Lower Columbia River - Flooding

RESULTS

Figure 2: Flooding Days – HYSIM Results for all NTS scenarios (see Note)

	Scen A	Scen B	Scen C	Scen D
Max	28	28	28	26
90th	6.6	6.6	6.6	5.2
Mean	1.9	1.9	1.9	1.6
Med	0	0	0	0
10th	0	0	0	0
Min	0	0	0	0



Note: *Control of potential flooding downstream of Arrow Reservoir is managed within the Columbia River Treaty. BC Hydro will take mitigative action in any case where there is risk of downstream flooding.*

SUMMARY CONSEQUENCE TABLE

Consequence Table – Arrow Soft Constraints

Objective	Attribute	Direction	Units	MSIC Type	MSIC Val	A (Full Utilization)	B (Moderate & Flex)	C (Low Utilization)	D (none)
Arr - SC - Recreation	1435 < days < 1440	H	days	A	7	26	22	27	63
Arr - SC - Fish	days > 1424	H	days	A	7	41	39	49	72
Arr - SC - Vegetation (early)	days > 1424 (may-july)	L	days	A	7	57	54	58	58
Arr - SC - Vegetation (late)	days > 1424 (aug - sept)	L	days	A	7	42	40	45	55
Arr - SC - Heritage	days <= 1430	H	days	A	7	280	288	277	202
Arr - SC - Erosion	days >= 1440	L	days	A	7	9	7	9	8
Arr - SC - Wildlife (nesting bird)	days < 1424	H	days	A	7	34	37	34	34
Arr - SC - Wildlife fall migrants)	days < 1437	H	days	A	7	85	85	85	58

Consequence Table

Objective	Attribute	Direction	Units	MSIC Type	MSIC Val	A (Full Utilization)	B (Moderate & Flex)	C (Low Utilization)	D (none)
Kin - Navigation	Total site-days / year (5 sites)	H	days	A	7	1,221	1,241	1,279	1,385
Kin - Boat Access	2395 < days < 2475	H	days	A	7	99	100	102	105
Kin - Shoreline Access	2444 < days < 2473	H	days	A	7	50	44	45	46
Kin - Heritage	Weighted days	L	days	A	7	208	206	213	233
Mid-Col - Rec - Boat Access	days > 1435	H	days	A	7	36	30	36	71
Mid-Col - Rec - Shore Access	days < 1435	H	days	A	7	117	123	117	82
Arr - Boat Access	1435 < days < 1444	H	days	A	7	33	27	34	68
Arr - Shoreline Access	1425 < days < 1435	H	days	A	7	58	59	61	39
Arr - Heritage	Weighted days	L	days	A	7	212	209	216	262
Arr - Dust	days < 1410	L	days	A	7	43	42	43	28
Arr - SC - Recreation	1435 < days < 1440	H	days	A	7	26	22	27	63
Arr - SC - Fish	days > 1424	H	days	A	7	41	39	49	72
Arr - SC - Vegetation (early)	days > 1424 (may-july)	L	days	A	7	57	54	58	58
Arr - SC - Vegetation (late)	days > 1424 (aug - sept)	L	days	A	7	42	40	45	55
Arr - SC - Heritage	days <= 1430	H	days	A	7	280	288	277	202
Arr - SC - Erosion	days >= 1440	L	days	A	7	9	7	9	8
Arr - SC - Wildlife (nesting bird)	days < 1424	H	days	A	7	34	37	34	34
Arr - SC - Wildlife fall migrants)	days < 1437	H	days	A	7	85	85	85	58
LCR - Boat Access	71000 < days < 103000	H	days	A	7	67	65	66	69
LCR - Shoreline Access	60000 < days < 99000	H	days	A	7	87	87	87	92
LCR - Flooding at Genelle	days > 165 kcfs	L	days	A	n/a	0	0	0	0
Power Generation	Incremental Cost	L	$M/yr	A	0.5	$ 0.00	$ 0.10	$ 0.60	$ 11.80