

APPENDIX J

CALCULATION OF LOAD ALLOCATIONS

Supporting the Fox Illinois River Basin Total Maximum Daily Load (TMDL) for Phosphorus and Total Suspended Solids

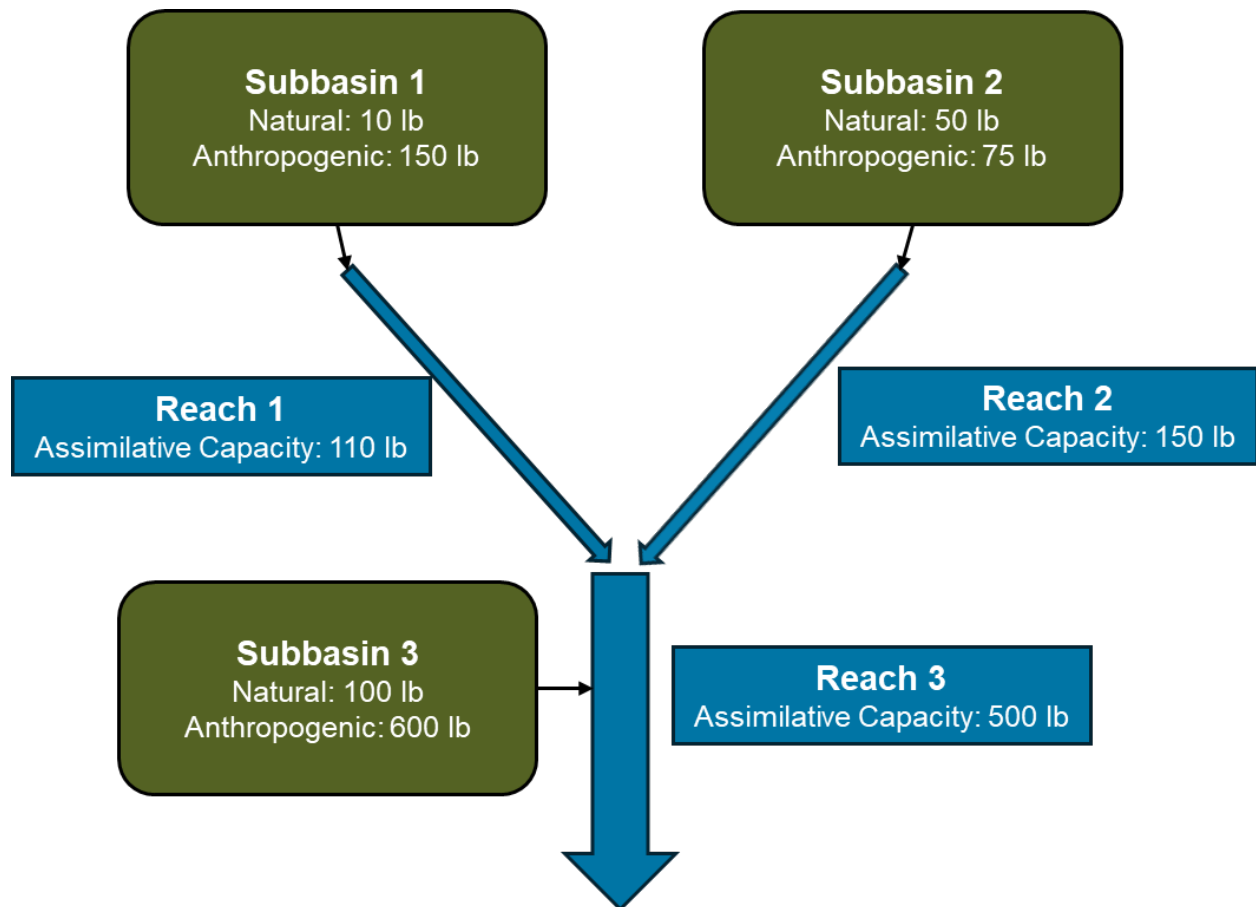
EXAMPLE 1. CALCULATION OF LOCAL ALLOCATIONS

The following section provides a summary of the steps used to calculate local reductions.

Baseline Conditions

Source	Baseline Loads (lb)			Total
	Reach 1	Reach 2	Reach 3	
Natural	10	50	100	160
Anthropogenic	150	75	600	825
Reserve Capacity				
Delivered DS	160	125	700	985

Reach	Assimilative Capacity (lb)
1	110
2	150
3	500



Step 1. Calculate reduction required for Reach 1

Natural Baseline Load (BL_{nat}) = **10 lb**

Anthropogenic Baseline Load (BL_{anth}) = **150 lb**

Assimilative Capacity for Reach 1 (AC) = **110 lb**

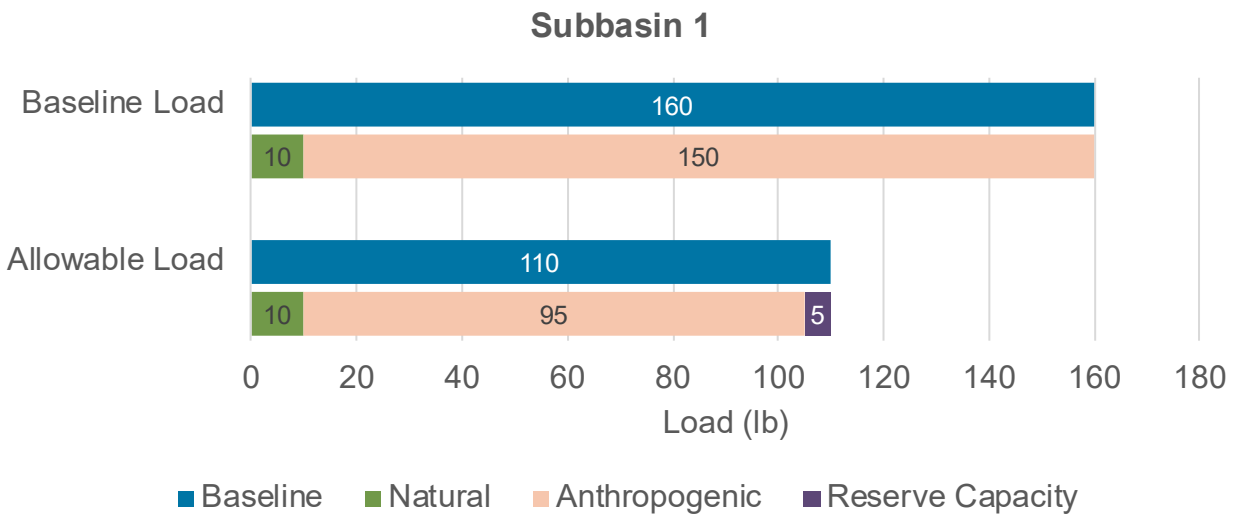
Assimilative Capacity for Anthropogenic Loads (AC_{anth}) = $AC - BL_{nat} = 110 \text{ lb} - 10 \text{ lb} = \mathbf{100 \text{ lb}}$

Reserve Capacity (RC) = $5\% * AC_{anth} = 0.05 * 100 \text{ lb} = \mathbf{5 \text{ lb}}$

Allowable Load for Anthropogenic Loads (AL_{anth}) = $AC_{anth} - RC = 100 \text{ lb} - 5 \text{ lb} = \mathbf{95 \text{ lb}}$

$$\% \text{ Reduction} = \frac{BL_{anth} - AL_{anth}}{BL_{anth}} = \frac{150 \text{ lb} - 95 \text{ lb}}{150 \text{ lb}} = \mathbf{36.7\%}$$

Source	Baseline Loads (lb)	Allocated Loads (lb)
Natural	10	10
Anthropogenic	150	95
Reserve Capacity		5
Delivered Downstream	160	110
% Reduction = 36.7%		



Step 2. Calculate reduction required for Reach 2

Natural Baseline Load (BL_{nat}) = **50 lb**

Anthropogenic Baseline Load (BL_{anth}) = **75 lb**

Assimilative Capacity for Reach 2 (AC) = **150 lb**

Assimilative Capacity for Anthropogenic Loads (AC_{anth}) = $AC - BL_{nat} = 150\text{ lb} - 50\text{ lb}$
 = **100 lb**

$AC_{anth} > BG_{anth}$ so % Reduction=0% and RC calculated based on existing loads

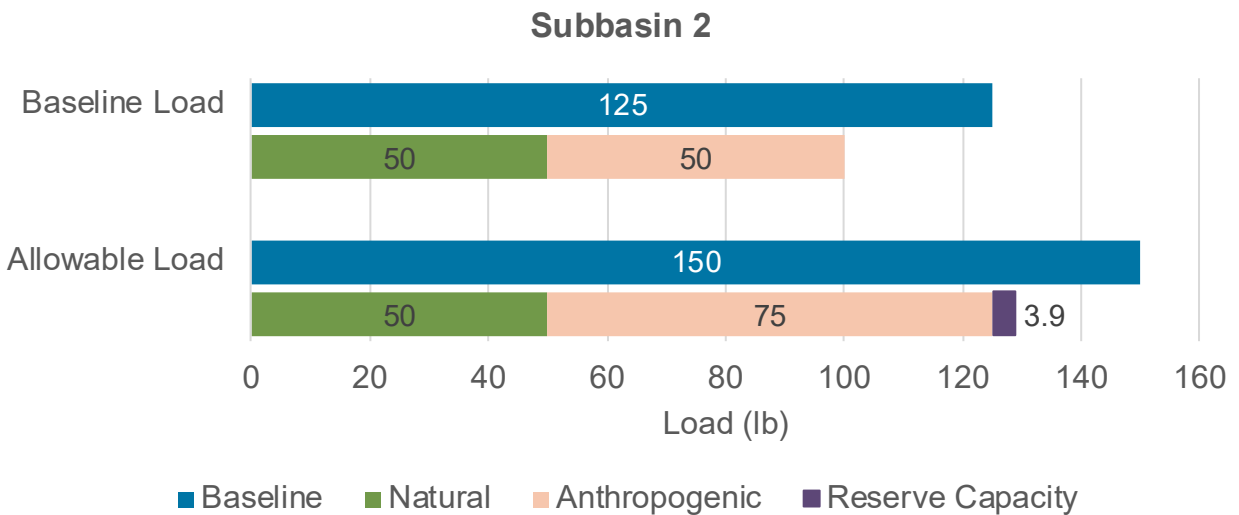
Reserve Capacity (RC) = $5\% * (BL_{anth} + RC) = 0.05 * BL_{anth} + 0.05 * RC$

$0.95 * RC = 0.05 * BL_{anth}$

$RC = 0.0526 * BL_{anth} = 0.0526 * 75\text{ lb} = \mathbf{3.9\text{ lb}}$

Load Delivered Downstream = $BL_{nat} + BL_{anth} + RC = 50\text{ lb} + 75\text{ lb} + 3.9\text{ lb} = \mathbf{128.9\text{ lb}}$

Source	Baseline Loads (lb)	Allocated Loads (lb)
Natural	50	50
Anthropogenic	75	75
Reserve Capacity		3.9
Delivered Downstream	125	128.9
% Reduction = 0%		



Step 3. Calculate reduction required for Reach 3

Natural Baseline Load (BL_{nat}) = **100 lb**

Anthropogenic Baseline (BL_{anth}) = **600 lb**

Loads from Upstream Reaches (L_{US}) = Load from Reach 1 + Load from Reach 2
 = 110 lb + 128.9 lb = **238.9 lb**

Assimilative Capacity for Reach 3 (AC) = **500 lb**

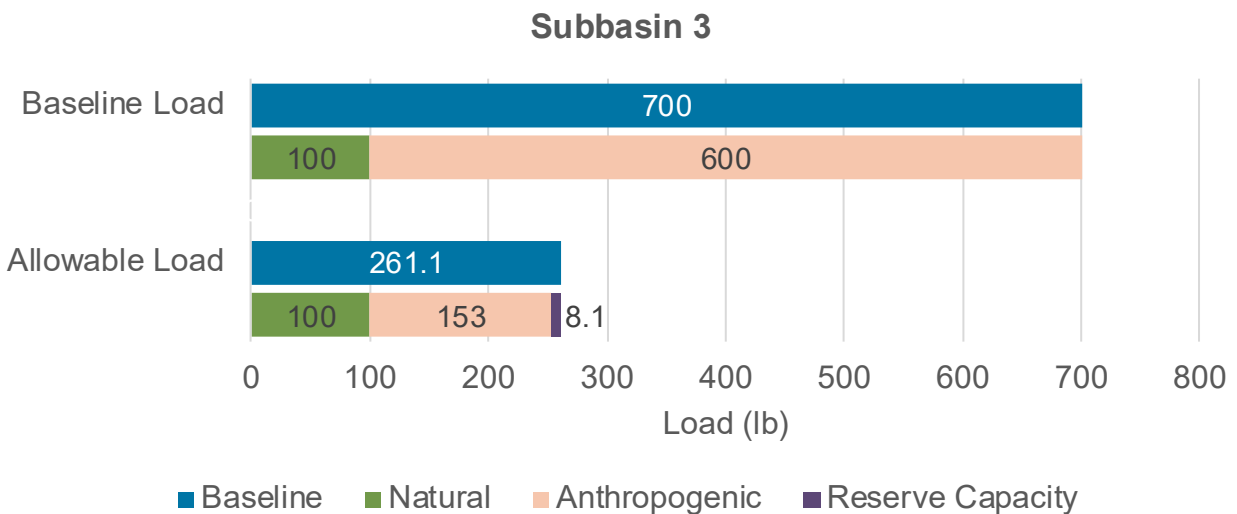
Assimilative Capacity for Anthropogenic Loads (AC_{anth}) = $AC - BL_{nat} - L_{US}$
 = 500 lb - 100 lb - 238.9 lb = **161.1 lb**

Reserve Capacity (RC) = 5% * AC_{anth} = 0.05 * 161.1 lb = **8.1 lb**

Allowable Load for Anthropogenic Loads (AL_{anth}) = $AC_{anth} - RC$ = 161.1 lb - 8.1 lb
 = **153.0 lb**

$$\% \text{ Reduction} = \frac{BL_{anth} - AL_{anth}}{BL_{anth}} = \frac{600 \text{ lb} - 153.0 \text{ lb}}{600 \text{ lb}} = \mathbf{74.5\%}$$

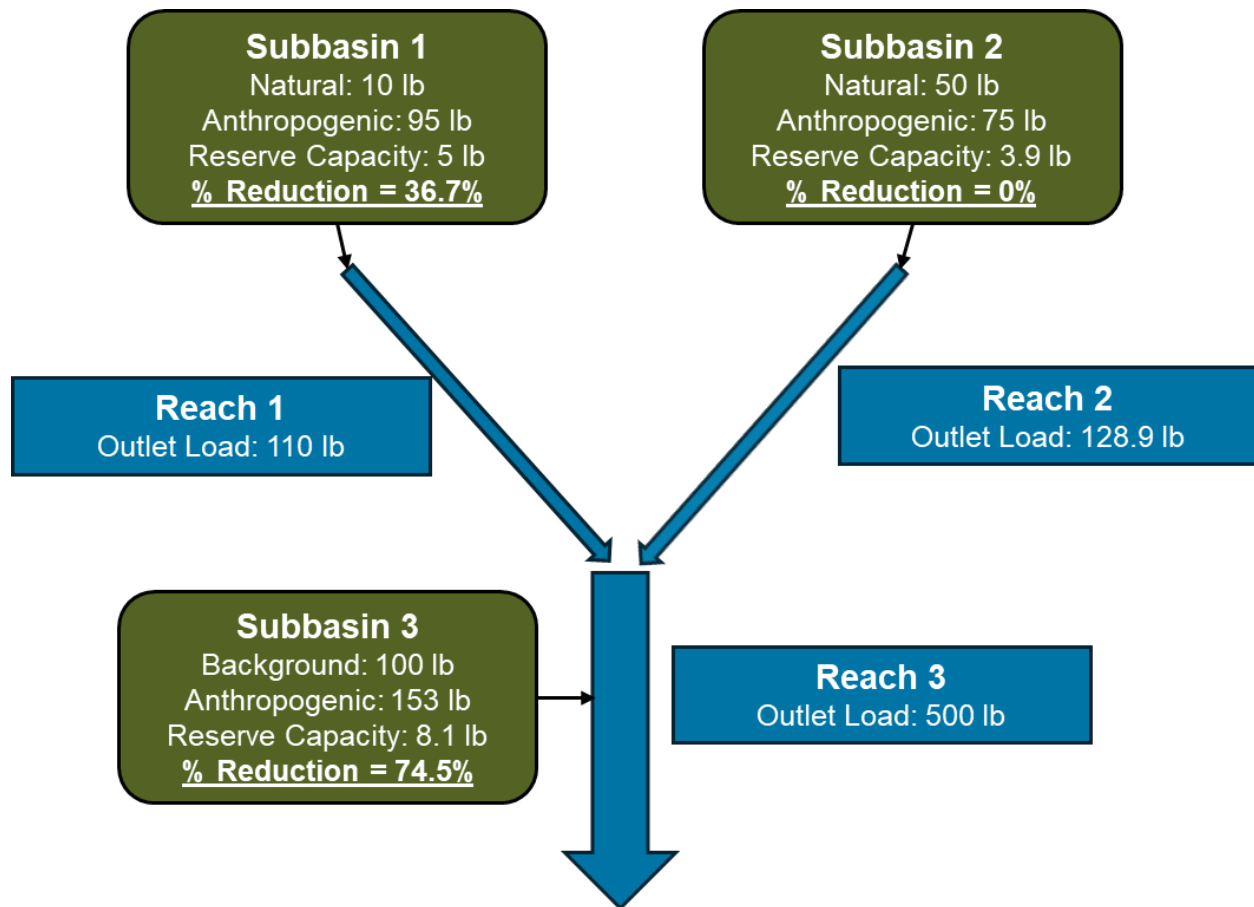
Source	Baseline Loads (lb)	Allocated Loads (lb)
Upstream Loads	238.9	238.9
Natural	100	100
Anthropogenic	600	153
Reserve Capacity		8.1
Delivered Downstream	938.9	500.0
% Reduction = 74.5%		



Final Local Allocations

Table of Final Load Allocations (BL = Baseline Load, AL = Allowable Load)

Source	BL Reach 1 (lb)	BL Reach 2 (lb)	BL Reach 3 (lb)	BL Total (lb)	AL Reach 1 (lb)	AL Reach 2 (lb)	AL Reach (lb)	AL Total (lb)
Natural	10	50	100	160	10	50	100	160
Anthropogenic	150	75	600	825	95	75	153	323
Reserve Capacity					5.0	3.9	8.1	17.0
Delivered DS	160	125	700	985	110.0	128.9	261.1	500
				Percent Red.	37%	0%	74.5%	



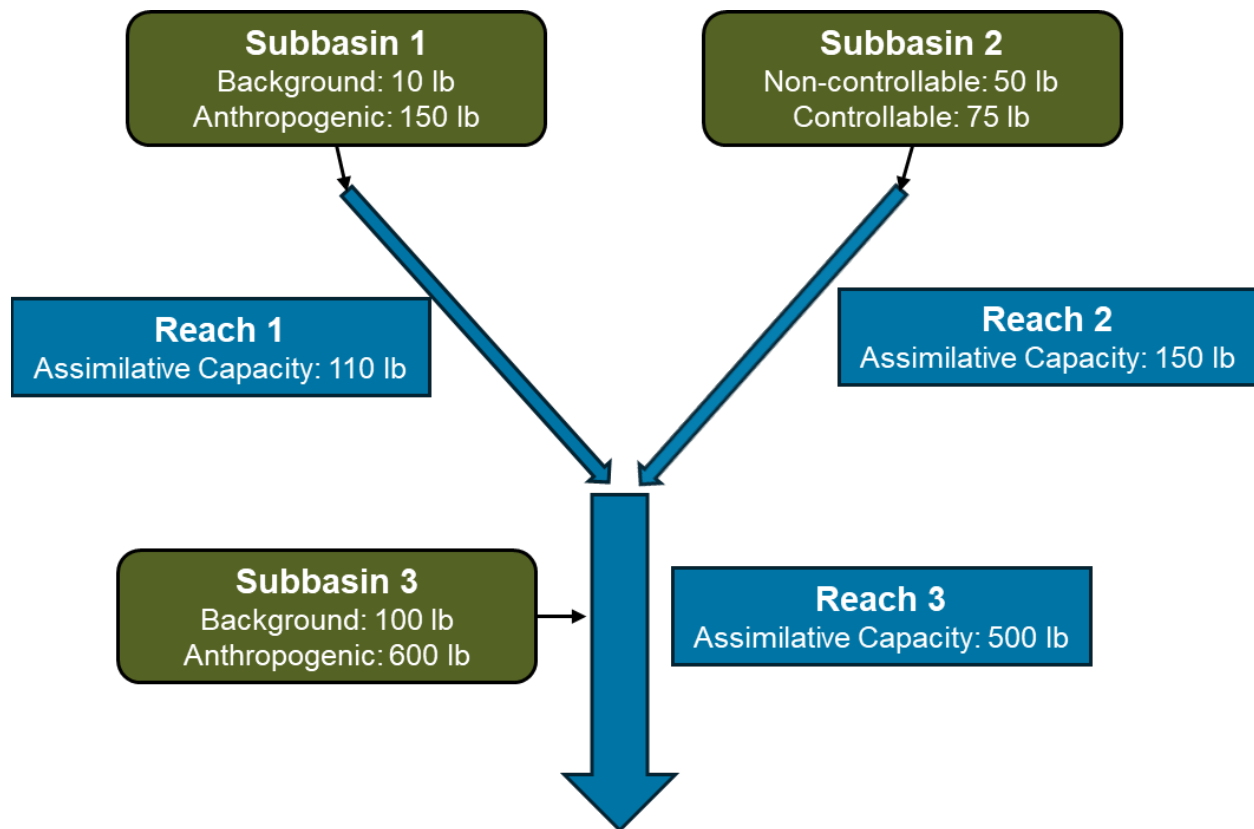
EXAMPLE 2. CALCULATION OF DOWNSTREAM LOAD

The following section provides a summary of the steps used to calculate local reductions.

Baseline Conditions

Source	Baseline Loads (lb)			Total
	Reach 1	Reach 2	Reach 3	
Natural	10	50	100	160
Anthropogenic	150	75	600	825
Reserve Capacity				
Delivered DS	160	125	700	985

Reach	Assimilative Capacity (lb)
1	110
2	150
3	500



Step 1. Calculate local reductions (Example 1)

$$\text{Subbasin 1 \% Reduction} = \mathbf{36.7\%}$$

$$\text{Subbasin 2 \% Reduction} = \mathbf{0\%}$$

$$\text{Subbasin 3 \% Reduction} = \mathbf{74.5\%}$$

Step 2. Calculate cumulative loads to determine downstream reductions at Reach 3

$$\begin{aligned} \text{Total Natural Baseline Load from Upstream Subbasins} &= BL_{nat,tot} = 10 \text{ lb} + 50 \text{ lb} + 100 \text{ lb} \\ &= \mathbf{160 \text{ lb}} \end{aligned}$$

$$\begin{aligned} \text{Total Anthropogenic Baseline Load from Upstream Subbasins} &= BL_{anth,tot} \\ &= 150 \text{ lb} + 75 \text{ lb} + 600 \text{ lb} = \mathbf{825 \text{ lb}} \end{aligned}$$

Step 3. Calculate percent reduction for Reach 3 from all cumulative sources

$$\text{Assimilative Capacity for Reach 3 (AC)} = \mathbf{500 \text{ lb}}$$

$$\begin{aligned} \text{Assimilative Capacity for Anthropogenic Loads (AC}_{anth}) &= AC - BG_{nat,tot} = 500 \text{ lb} - 160 \text{ lb} \\ &= \mathbf{340 \text{ lb}} \end{aligned}$$

$$\text{Reserve Capacity (RC)} = 5\% * AC_{anth} = 0.05 * 340 \text{ lb} = \mathbf{17 \text{ lb}}$$

$$\text{Allowable Load for Anthropogenic Loads (AL}_{anth}) = AC_{anth} - RC = 340 \text{ lb} - 17 \text{ lb} = \mathbf{323 \text{ lb}}$$

$$\% \text{ Reduction} = \frac{BL_{anth} - AL_{anth}}{BL_{anth}} = \frac{825 \text{ lb} - 323 \text{ lb}}{825 \text{ lb}} = \mathbf{60.8\%}$$

Step 4. Compare upstream local reductions to downstream reductions

If local % reduction from Subbasin 1 or 2 > downstream % reduction, local % reduction must be used and downstream % reduction must be calculated.

For example, local % reduction from Subbasin 1 and Subbasin 2 < downstream % reduction, so downstream % reduction applied to all basins.

Step 5. Compute reserve capacity for each subbasin

$$\text{Allowable Anthropogenic Load (AL}_{anth}) = BL_{anth} * (1 - \% \text{ Reduction}) = BL_{anth} * (1 - 0.0608)$$

$$\text{Subbasin 1: } 150 \text{ lb} * (1 - 0.0608) = \mathbf{58.7 \text{ lb}}$$

$$\text{Subbasin 2: } 75 \text{ lb} * (1 - 0.0608) = \mathbf{29.4 \text{ lb}}$$

$$\text{Subbasin 3: } 600 \text{ lb} * (1 - 0.0608) = \mathbf{234.9 \text{ lb}}$$

$$\text{Subbasin Reserve Capacity (RC)} = 5\% * (AL_{anth} + RC) = 0.05 * AL_{anth} + 0.05 * RC$$

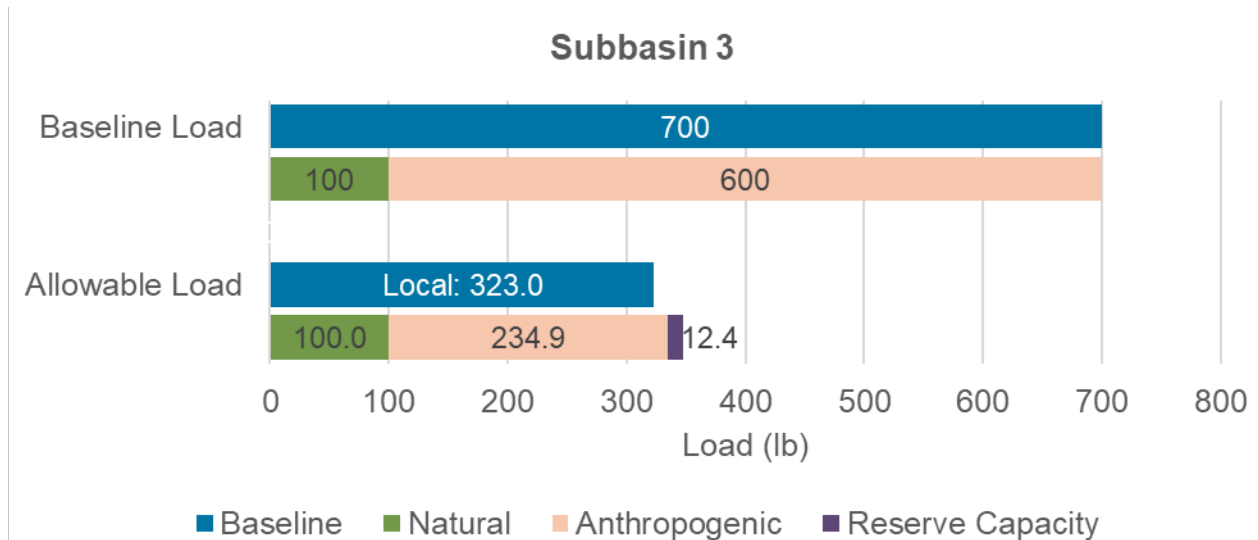
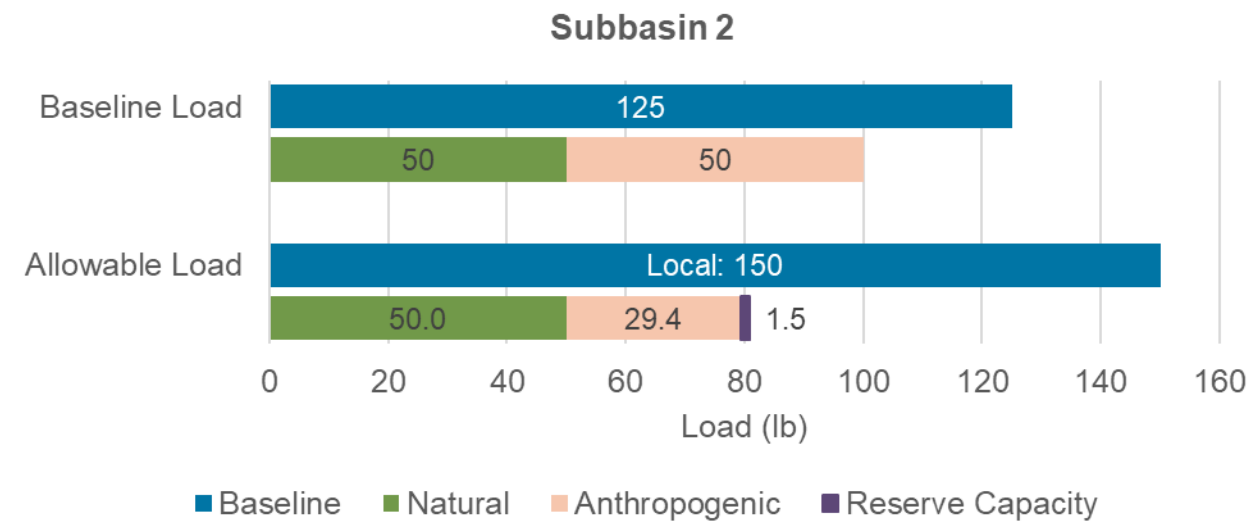
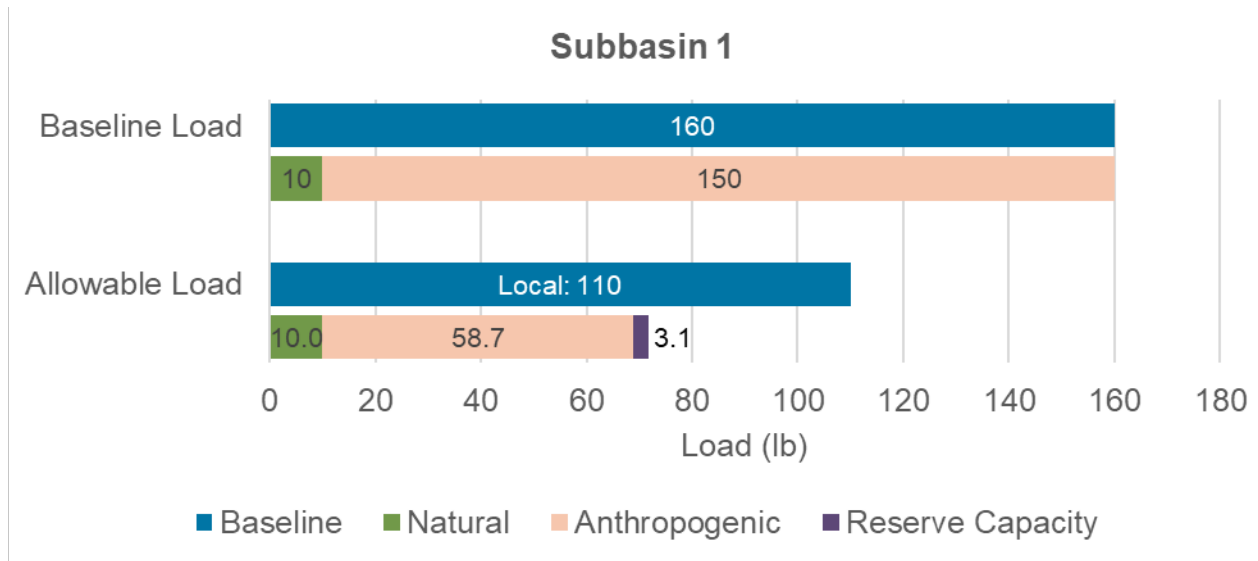
$$0.95 * RC = 0.05 * AL_{anth}$$

$$RC = 0.0526 * AL_{anth}$$

$$\text{Subbasin 1: } = 0.0526 * 58.7 \text{ lb} = \mathbf{3.1 \text{ lb}}$$

$$\text{Subbasin 2: } = 0.0526 * 29.4 \text{ lb} = \mathbf{1.5 \text{ lb}}$$

$$\text{Subbasin 3: } = 0.0526 * 234.9 \text{ lb} = \mathbf{12.4 \text{ lb}}$$



Final Downstream Allocations

Table of Final Load Allocations (BL = Baseline Load, AL = Allowable Load)

Source	BL	BL	BL	BL Total (lb)	AL	AL	AL	AL Total (lb)
	Reach 1 (lb)	Reach 2 (lb)	Reach 3 (lb)		Reach 1 (lb)	Reach 2 (lb)	Reach 3 (lb)	
Natural	10	50	100	160	10	50	100	160
Anthropogenic	150	75	600	825	58.7	29.4	234.9	323
Reserve Capacity					3.1	1.5	12.4	17
Delivered DS	160	125	700	985	71.8	80.9	347.3	500
% Reduction = 60.8%								

