APPENDIX G: Equations for calculating climate threat risk factor values

For each hydrographic area, we applied the following equations using the seven different LOCA models:

$$FC(j) = (1 - NORM_j) \times \frac{AVE_j\left(\sum_{\substack{0 \le i \le m \\ 0 < k < n}} f(SPEI(i,k))\right)}{(m \times max_{spei})} \qquad \textit{Eq. G-1}$$

$NORM_j$ = normalized variance (VAR) of sums (Sum) for a hydrographic area j based on the observed maximum variance (MAX) =

$$\frac{VAR(sum_{1,j}, sum_{2,j}, \ldots, sum_{7,j})}{MAX(VAR_{j=1}, VAR_{j=2}, \ldots, VAR_{j=y})} \qquad \textit{Eq. G-2}$$

$f(SPEI(I,k))$ = abs($SPEI(i,k)$) for year i and LOCA k if SPEI is ≤ -1; otherwise it is 0 *Eq. G-3*

Where:

$FC(j)$ = climate threat risk factor value in hydrographic area j that varies from 0 to 1
max_{spei} = maximum absolute value of the observed SPEI
$sum_{k,j}$ = temporal sum of SPEIs ≤ -1 from years 2022 to 2060 in hydrographic area j of LOCA k
y = number of hydrographic areas = 256
m = number of years = 38
n = number of models = 7

In Equation G-1, the first portion to the left of the multiplication sign accounts for the variability in SPEI between the different LOCA models. We used a normalized variance approach, described mathematically in Equation G-2. The second portion of Equation G-1 estimates the amount of drought conditions in the future and is normalized by dividing the raw estimate for each basin by the maximum observed SPEI. Equation G-3 specifies that SPEI values less than or equal to -1 (i.e., droughty conditions) are included in the calculation. Anything less droughty than -1 standard deviation have a value of 0 for that year and LOCA model in Equation G-3.

After the $FC(j)$ values had been calculated for all hydrographic areas, they were normalized again by dividing by the largest $FC(j)$ value. This resulted in the hydrographic area with the largest $FC(j)$ value (i.e., the hydrographic area with the highest risk) having a value of 1.0, the hydrographic area with the highest variance having a value of 0.0, and all other hydrographic areas having values in between these for the climate threat risk factor.

Example: y = 2 hydrographic areas, n = 2 LOCA models, m = 3 years of SPEI values
For hydrographic area A and two LOCA models 1 and 2 for 3 years of SPEI values

- LOCA model 1:
  - SPEI for year 1 = -3, SPEI for year 2 = -1, SPEI for year 3 = -0.5 → $sum_{1,A}$ = 3+1+0 = 4
- LOCA model 2:
  - SPEI for year 1= -2, SPEI for year 2 = -1.5, SPEI for year 3 = 2 → $sum_{2,A}$ = 2+1.5+0 = 3.5
- Average = (4+3.5)/2 = 3.75
- Variance = VAR (4, 3.5) = 1.125

For hydrographic area B and two LOCA models 1 and 2 for 3 years of SPEI values

- LOCA model 1:
  - SPEI for year 1 = 1, SPEI for year 2 = -1, SPEI for year 3 = -0.5 → $sum_{1,B}$ = 0+1+0 = 1
- LOCA model 2:
  - SPEI for year 1 = -3, SPEI for year 2 = 2, SPEI for year 3 = 2 → $sum_{2,B}$ = 3+0+0 = 3
- Average = (1+3)/2 = 2
- Variance = VAR (1,3) = 2

Climate effect for hydrographic area A =

$$FC(A) = \left(1 - \frac{1.125}{MAX(1.125,2)}\right) \times \frac{3.75}{(3 \times 3)} = 0.18$$

Climate effect for hydrographic area B =

$$FC(B) = \left(1 - \frac{2}{MAX(1.125,2)}\right) \times \frac{2}{(3 \times 3)} = 0.00$$

If there were only these two hydrographic areas in Nevada, then the final normalizing process would make $FC(A)_{\text{final}}$ = 1.0 and $FC(B)_{\text{final}}$ = 0.0 after dividing both of the above values by 0.18, the largest *FC*(*j*) value.