head: at $\tau = 0, R = 0$; as $\tau \to \infty$, the exponential terms vanish and $R \to 1$ (complete transmission). Curve matching at the inflection point (τ* = 30 days) yielded D = 290.96 m²/d, assuming b = 151.8 m. This provides a physically grounded estimate of vertical leakage and quantifies swamp–aquifer connectivity in this low-relief coastal plain system.

All data processing and analyses were performed using Matlab. The isotope mixing calculations were straightforward algebraic derivations from the measured values. Uncertainty in the computed swamp-water fraction, f_{swamp}, was evaluated by propagating the standard deviation of the δ values following Genereux (1998):

$$W_{f_{swamp}} = \left\{\left[\frac{\delta_{regional}-\delta_{well}}{(\delta_{regional}-\delta_{swamp})^2} W_{\delta_{swamp}}\right]^2 + \left[\frac{\delta_{well}-\delta_{swamp}}{(\delta_{regional}-\delta_{swamp})^2} W_{\delta_{gw}}\right]^2 + \left[\frac{-1}{(\delta_{regional}-\delta_{swamp})} W_{\delta_{well}}\right]^2\right\}^{\frac{1}{2}} \quad \text{(Eq. 4)}$$

3. Results

3.1 Stable isotopic evidence of vertical exchange

The stable isotope measurements show a clear fingerprint of Okefenokee Swamp water in the underlying Upper Floridan Aquifer. **Figure 2A** shows a crossplot of $\delta^{18}O$ and $\delta^{2}H$ of regional UFA groundwater from Flowpaths 1 and 2 in (Clark *et al* 1997), and swamp surface waters and groundwater from UFA beneath or near the swamp collected in 2025. Several notable patterns emerge. First, the swamp surface water is relatively enriched in heavy isotopes ($\delta^{18}O \approx -1.7 \pm 0.6$, $\delta^{2}H \approx -7.0 \pm 3.1$) compared to regional groundwater ($\delta^{18}O \approx -3.9 \pm 0.4$, $\delta^{2}H \approx -22.6 \pm 2.7$). By contrast, groundwater from the UFA beneath or near the swamp is significantly different ($\delta^{18}O \approx -2.6 \pm 0.38$, $\delta^{2}H \approx -9.8 \pm 1.9$) from regional background. In 2025, wells tapping the UFA near the swamp were found to be even more enriched, with one well measuring $\delta^{18}O \approx -1.8$ ‰, $\delta^{2}H \approx -7$ ‰ – nearly indistinguishable from the swamp surface water values. These data strongly indicate mixing of swamp-derived water into the aquifer. Groundwater in the aquifer directly beneath the swamp has an isotopic signature shifted toward that of swamp water, whereas regional groundwater remains distinctly lighter. This spatial isotopic contrast – heavy under the swamp vs. lighter away – is exactly what one would expect if swamp water were leaking downward and dominating the recharge under the swamp.