b. Wind setup is a required component in the determination of freeboard. For shallow reservoirs (less than 16 feet in depth for the purpose of determining setup), wind setup is a particularly important component of freeboard and may even exceed the wave run-up component in magnitude. Two methods are available for determining wind setup: the Zeider Zee equation, which is applicable to reservoirs with average depths greater than 16 feet, and the Bretschneider Method, which is applicable to reservoirs with average depths less than 16 feet.

(1) The most widely used wind setup equation as applied to USACE reservoirs is the Zeider Zee equation. The Zeider Zee equation is described in both EM 1110-2-1414 and EM 1110-2-1420. It is presented here as Equation C-2. Zeider Zee normally results in the highest wind setup determination of the three methods.

$$S = \frac{U^2 F}{CD} \tag{C-2}$$

where:

S = wind setup above the stillwater elevation that would prevail with zero wind action, feet or meters

U = average wind speed over the fetch distance F, miles per hour or kilometers per hour

F = fetch distance, miles or kilometers

C = 1,400 for English units and 62,000 for Metric units

D = average depths of water generally along the fetch line

The fetch distance (F) used in the above formula should be the longest fetch distance to the structure (usually somewhat longer than the effect fetch, F_e).

(2) Although the Zeider Zee equation is commonly suggested for determining wind setup in reservoirs, the Zeider Zee equation may yield results that excessively overestimate wind setup at shallower water depths. The recommended alternative to the Zeider Zee equation at lower impoundment depths (average stillwater depth less than 16 feet including surcharge depth), is the Bretschneider method (Bretschneider 1953). For an enclosed reservoir the effective stress parameter in the Bretschneider method is presented in an integrated form in Equation C-3.

$$\frac{\kappa U^2 F}{g d^2} = \sum_{i=1}^{i=M} \left(\frac{\kappa U^2 \Delta x}{g (d_i)^2} \right) \tag{C-3}$$

where:

κ = a constant equal to 3.3 x 10-6 (dimensionless)