# APPENDIX E

## TRANSFORMATION OF ANISOTROPIC SOIL CONDITIONS TO ISOTROPIC SOIL CONDITIONS

**E-l. General.** All of the analytical methods for computing seepage through a permeable deposit are based on the assumption that the permeability of the deposit is isotropic. However, natural soil deposits are stratified to some degree, and the average permeability parallel to the planes of stratification is greater than the permeability perpendicular to these planes. Thus, the soil deposit actually possesses anisotropic permeability, with the permeability in the horizontal direction usually the greatest. To construct a flow net or make a mathematical analysis of the seepage through an anisotropic deposit, the dimensions of the deposit and the problem must be transformed so that the permeability is isotropic. Each permeable stratum of the deposit must be separately transformed into isotropic conditions. If the seepage flows through more than one stratum (isotropically transformed), the analysis can be made by a flow net constructed to account for permeability of the various strata.

**E-2. Anisotropic stratum.** A homogeneous, anisotropic stratum can be transformed into an isotropic stratum in accordance with the following equation:

$$\bar{y} = y\sqrt{\frac{k_h}{k_v}} \qquad \text{(E-1)}$$

where

$\bar{y}$ = transformed vertical dimension
$y$ = actual vertical dimension
$k_h$ = permeability in the horizontal direction
$k_v$ = permeability in the vertical direction

The horizontal dimensions of the problem would remain unchanged in this transformation. The permeability of the transformed stratum, to be used in all equations for flow or drawdown, is as follows:

$$\bar{k} = \sqrt{k_v k_h} \qquad \text{(E-2)}$$

where $\bar{k}$ equals the transformed coefficient of permeability.

**E-3. Effective well penetration.** In a stratified aquifer, the effective well penetration usually differs from that computed from the ratio of the length of well screen to total thickness of aquifer. To determine the required length of well screen W to achieve an effective penetration $\bar{W}$ in a stratified aquifer, the following procedure can be used. This method is used in analyses to determine penetration depths needed to obtain required discharge from partially penetrating wells or wellpoints. Each stratum of the previous foundation or aquifer with thickness d and horizontal and vertical permeability coefficients $k_h$ and $k_v$, respectively, is first transformed using equation (E-l) into an isotropic layer of thickness $\bar{d}$, where

$$= \bar{d}\sqrt{\frac{k_h}{k_v}}$$

The transformed coefficient of permeability of each stratum from equation (E-2) is

$$\bar{k} = \sqrt{k_h k_v}$$

The thickness of the equivalent homogeneous isotropic aquifer is

$$\bar{D} = \sum_{m=1}^{m=n} \bar{d}_m \qquad \text{(E-3)}$$

where n equals the number of strata in the aquifer.
The effective permeability of the transformed aquifer is

$$\bar{k}_e = \frac{\sum_{m=1}^{m=n} \bar{k}_m \bar{d}_m}{\bar{D}} \qquad \text{(E-4)}$$

where n equals the number of strata in the aquifer. The effective well-screen penetration into the transformed aquifer is

$$\bar{W} = \frac{w_\ell k_{h\ell} + \sum_{m=1}^{m=\ell-1} d_m k_{hm}}{\bar{k}_e} \qquad \text{(E-5)}$$

where

$w_\ell$ = actual well penetration in strata $\ell$
1 = number of strata penetrated by well

The penetration of the well screen in the transformed aquifer (expressed as a decimal) is $\bar{W}/\bar{D}$, where $\bar{W}$ and $\bar{D}$ are obtained from equations (E-5) and (E-3), respectively.