On the basis of theoretical and experimental investigations, criteria have been established for topographic similitude of waterway scours, and scale factors obtained for translating laboratory data to full-scale conditions [1, 2].

As the criteria, use has been made of kinetic parameters and \( F_{r*} d = u^* \frac{d}{g} \) (where \( u^* \) is the dynamic velocity, and \( d \) is the diameter of the material forming the waterway bed). The scale effect, which occurs both with geometric and distorted models, has also been established; this effect is taken into account by the dimensionless factors

\[
M_f = \frac{k_f}{k_m} \quad \text{and} \quad M_x = \frac{x_f}{x_m}.
\]

The indices \( f \) and \( m \) denote the respective characteristics for the full-scale and model conditions. The flow parameter \( k \) is related to \( Re_{r*} \Delta = \frac{u^* \Delta}{\nu} \) (where \( \Delta \) is the linear characteristic of roughness, and \( \nu \) is the kinematic coefficient of viscosity) by the expression

\[
k = \frac{k_{cr, \min}}{R e_{r*} \Delta},
\]

where \( k_{cr, \min} = 0.693 \).

The kinematic turbulence characteristic \( x \) is related to the relative boundary-layer thickness \( h/\delta \) by an expression such as [3]

\[
x = \frac{\delta}{k - \delta},
\]

Full-scale investigations by the Moscow Institute of Railroad Transport Engineers (MIIT), carried out on the Amudar'ya River and canals in natural waterways, showed that the magnitude of \( x \) characterizes the phases of the motion of deposits (corrugation, ridge, etc.), and the effect of turbidity on the hydraulic flow resistance [3].

When modeling nonscouring waterways it is possible that \( x_f = x_m \) \((M_x = 1)\); but to achieve topographic similitude in erodible waterways, \( x_f = x_m \) \((M_x = 1)\).

In order to substantiate the possibility of a distorted modeling of scour at hydraulic structures, the variation of parameter \( k \) with Chezy's dimensionless coefficient \( C/\sqrt{g} \) (Fig. 1), plotted from laboratory tests, is presented. This shows that there is a threshold value of \( k_{\min} \), which characterizes the initial period of topographic change in an erodible waterway (the crest point). With \( k < k_{\min} \), the deposits are not moved; with \( k > k_{\min} \), different phases of motion are observed [3].

From an analysis based on the relationship in Fig. 1, it is possible to write the expression

\[
k_{\min} = \frac{k_{\max}}{\exp(x_{cr} \left( \frac{C}{\sqrt{g}} \right))},
\]

where \( k_{\max} \approx 2.83 \), and \( k_{cr} \approx 0.08-0.10 \).

The supplementary condition for similitude, for both the geometric \((M_I = M_B = M_H)\) and distorted

TABLE 1. Comparison of the Formulas of Different Authors, for Translating the Depth of a Local Scour $\Delta h_m$ to Full-Scale Conditions, on the Basis of the General Expressions Given by Eqs. (8) and (9) in the Form $M_{\Delta h} = M_{\Delta h} \cdot M_{\mathrm{tr}} \cdot M_{\mathrm{t}} \cdot M_{\Delta h}$

<table>
<thead>
<tr>
<th>Author</th>
<th>$z_1$</th>
<th>$z_2$</th>
<th>$z_3$</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>O. Maggiolo and J. Borghi [9]</td>
<td>2</td>
<td></td>
<td>1.5</td>
<td>Scales $M_p$, $M_k$, and $M_x$ are not taken into account.</td>
</tr>
<tr>
<td>S. A. Sarsekeev [6]</td>
<td>1.33</td>
<td>0.33</td>
<td>0.33</td>
<td>A supplementary scale is introduced to indicate the degree of nonhomogeneity of the erodible material, but $M_k$ and $M_x$ are not taken into account.</td>
</tr>
<tr>
<td>B. I. Studenichnikov [7]</td>
<td>1.2</td>
<td></td>
<td>0.2</td>
<td>Scales $M_p$, $M_k$, and $M_x$ are not taken into account.</td>
</tr>
<tr>
<td>N. N. Surova [8]</td>
<td>1.12-1.29</td>
<td>-</td>
<td>0.25-0.5</td>
<td>Scales $M_p$, $M_k$, and $M_x$ are not taken into account.</td>
</tr>
<tr>
<td>V. S. Altunin [1, 2]</td>
<td>1.25-1.5</td>
<td>0.25-0.5</td>
<td>0.25-0.5</td>
<td>$M_k$ and $M_x$ take into account the scale effect; $z_4 = z_5 = 3-4$.</td>
</tr>
</tbody>
</table>

For an erodible waterway, with $v \leq (1.5-3) v_0$ (where $v_0$ is the nonscouring velocity) and $h/\delta \leq 15$, the time scale of topographic changes will be given by the expression

$$M_{\mathrm{tr}}' = M_{\mathrm{tr}} \cdot M_{\Delta h}^{1.5} M_{\mathrm{t}}^{1.5} M_{\mathrm{d}}^{0.5},$$

where $M_{\mathrm{tr}} = M_1 / (M_1)^{0.5}$ is the time scale which takes into account the flow velocity according to Froude; but with an increase in flow velocity to $v \geq (2.3$ to $3.3) v_0$ and $h/\delta > 15$,

$$M_{\mathrm{tr}}'' = M_{\mathrm{tr}} \cdot M_{\Delta h}^{1.5} M_{\mathrm{t}}^{0.5} M_{\mathrm{d}}^{1.5}.$$