ISBN 0-13-148192-4.

which yields

$$Q_{\max} = 0.146 \text{ m}^3/\text{s}$$

Therefore, the operating range for the weir is given by

$$\boxed{0.0223 \text{ m}^3/\text{s} < Q < 0.146 \text{ m}^3/\text{s}}$$

3.73. From the given data: $b = 3$ m, $h_1 + H_w = 4$ m, $Q = 5$ m^3/s, and

$$\frac{V_1^2}{2g} = \frac{(Q/A)^2}{2g} = \frac{[5/(3 \times 4)]^2}{2(9.81)} = 0.00885 \text{ m}$$

which gives

$$H = h_1 + \frac{V_1^2}{2g} = h_1 + 0.00885 \qquad (1)$$

The discharge rate is given by

$$Q = C_d\sqrt{g}b\left(\frac{2}{3}H\right)^{3/2} \qquad (2)$$

and

$$C_d = \frac{0.65}{(1 + H/H_w)^{1/2}} \qquad (3)$$

Combining Equations 1 to 3 and substituting the given data yields

$$\begin{aligned} Q &= \frac{0.65}{(1 + H/H_w)^{1/2}}\sqrt{g}b\left(\frac{2}{3}H\right)^{3/2} \\ 5 &= \frac{0.65}{\left[1 + \frac{h_1 + 0.00885}{4 - h_1}\right]^{1/2}}\sqrt{9.81}(3)\left[\frac{2}{3}(h_1 + 0.00885)\right]^{3/2} \end{aligned}$$

which gives

$$\begin{aligned} h_1 &= 1.53 \text{ m} \quad \text{or} \quad 3.84 \text{ m} \\ H_w &= 4 - h_1 = 0.16 \text{ m} \quad \text{or} \quad 2.47 \text{ m} \end{aligned}$$

This indicates two possible flow conditions:

Condition	h_1 (m)	H (m)	H_w (m)	H/H_w	C_d	$\sqrt{g}b\left(\frac{2}{3}H\right)^{3/2}$ (m^3/s)
1	1.53	1.54	2.47	0.62	0.51	9.77
2	3.84	3.85	0.16	24.06	0.13	38.64

Only Condition 1 gives a C_d that is typical of properly-operated broad-crested weirs (typically $0.527 < C_d < 0.540$), so take $\boxed{H_w = 2.47 \text{ m}}$.

For proper operation of the weir, take $h_1/L = 0.25$, so

$$L = \frac{h_1}{0.25} = \frac{1.53}{0.25} = \boxed{6.12 \text{ m}}$$

Therefore the weir should be 2.47 m high and 6.12 m long.

3.74. From the given data: $b = 3$ m, $Q = 1.5$ m^3/s, $y = 2$ m, and therefore

$$h_1 = 2 - H_w$$

and

$$\begin{aligned}
H &= h_1 + \frac{Q^2}{2gb^2(h_1+H_w)^2} = (2-H_w) + \frac{1.5^2}{2(9.81)(3)^2(2-H_w+H_w)^2} = 2.003 - H_w \\
C_d &= \frac{0.65}{\left(1+\frac{H}{H_w}\right)^{1/2}} = \frac{0.65}{\left(1+\frac{2.003-H_w}{H_w}\right)^{1/2}} = 0.459H_w^{1/2} \\
Q &= C_d b g^{1/2}\left(\frac{2}{3}H\right)^{3/2} \\
1.5 &= 0.459H_w^{1/2}(3)(9.81)^{1/2}\left[\frac{2}{3}(2.003-H_w)\right]^{3/2}
\end{aligned}$$

which gives

$$H_w = 0.056 \text{ m}, \; 1.33 \text{ m}$$

To achieve critical flow conditions over the weir use $\boxed{H_w = 1.33 \text{ m}}$, which corresponds to

$$h_1 = 2 - H_w = 2 - 1.33 = 0.67 \text{ m}$$

The weir length, L, is then given by the relation

$$\begin{aligned}
0.08 < &\; h_1/L < 0.33 \\
12.5 > &\; L/h_1 > 3.03 \\
12.5h_1 > &\; L > 3.03h_1 \\
12.5(0.67) > &\; L > 3.03(0.67) \\
8.38 \text{ m} > &\; L > 2.03 \text{ m}
\end{aligned}$$

Therefore a weir length in the range $\boxed{2.0 \text{ m} < L < 8.4 \text{ m}}$ would be satisfactory.

3.75. From the given data: $W = 0.91$ m, $H_a = 0.457$ m, $H_b = 0.320$ m. Therefore,

$$Q = 0.372W(3.281H_a)^{1.570W^{0.026}} = 0.372(0.91)(3.281 \times 0.457)^{1.570(0.91)^{0.026}} = \boxed{0.638 \text{ m}^3/\text{s}}$$

Check:

$$\frac{H_b}{H_a} = \frac{0.320}{0.457} = 0.70$$

This does not exceed the critical value in Table 3.9.

3.76. From the given data: $W = 6.10$ m, $H_a = 1.22$ m, $H_b = 1.10$ m.

$$Q = [2.29W + 0.474]H_a^{1.6} = [2.29(6.10) + 0.474](1.22)^{1.6} = 19.9 \text{ m}^3/\text{s}$$

Check:

$$\frac{H_b}{H_a} = \frac{1.10}{1.22} = 0.9 \qquad \text{flow is submerged}$$