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# Density Currents in Harbors Formulas

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# List of 27 Density Currents in Harbors Formulas

## Density Currents in Harbors

### 1) Average Depth of Harbor for Water Volume Exchanged during Entire Tide Period

$$\text{fx } h' = \frac{\left(\frac{V_w}{G} \cdot A_E\right)^{\frac{1}{2}}}{H^2}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b\_img.jpg\)](#)

$$\text{ex } 15.87659\text{m} = \frac{\left(\frac{50\text{m}^3/\text{s}}{0.1} \cdot 61\text{m}^2\right)^{\frac{1}{2}}}{11}$$

### 2) Average Harbor Depth

$$\text{fx } h' = \frac{\Delta h \cdot V}{P}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d\_img.jpg\)](#)

$$\text{ex } 4.2\text{m} = \frac{21\text{m} \cdot 6.4\text{m}^3}{32\text{m}^3}$$



### 3) Average Harbor Depth given Portion caused by Filling

$$fx \quad h' = \frac{\Delta h}{\alpha_f}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$ex \quad 6m = \frac{21m}{3.5}$$

### 4) Average River Density over one Tide Period given Relative Density

$$fx \quad \rho' = \frac{\rho_{\max} - \rho_{\min}}{H^2}$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$ex \quad 8kg/m^3 = \frac{100 - 12}{11}$$

### 5) Cross-Sectional Area of Entrance given Water Volume exchanged during entire Tide Period

$$fx \quad A_E = \frac{V_w}{G \cdot \sqrt{H^2 \cdot h'}}$$

[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$ex \quad 61.54575m^2 = \frac{50m^3/s}{0.1 \cdot \sqrt{11 \cdot 6m}}$$

### 6) Density Influence given Ratio of Water Volume entering Harbor per Tide

$$fx \quad \alpha_D = \alpha - \alpha_f$$

[Open Calculator !\[\]\(b64b40baaee5acddc1eab8538ba84754\_img.jpg\)](#)

$$ex \quad 6.5 = 10 - 3.5$$



### 7) Difference between High and Low Tide Levels given Portion caused by Filling

$$fx \quad \Delta h = h' \cdot \alpha_f$$

[Open Calculator !\[\]\(e78f798d4ea5c530c9db49e7d26e6b95\_img.jpg\)](#)

$$ex \quad 21m = 6m \cdot 3.5$$

### 8) Difference between High and Low Tide Levels given Tidal Prism of Harbor Basin

$$fx \quad \Delta h = \left( \frac{P}{V} \right) \cdot h'$$

[Open Calculator !\[\]\(05be7c7a8995decd503647c99211f7c2\_img.jpg\)](#)

$$ex \quad 30m = \left( \frac{32m^3}{6.4m^3} \right) \cdot 6m$$

### 9) Maximum River Density given Relative Density

$$fx \quad \rho_{max} = (H^2 \cdot \rho') + \rho_{min}$$

[Open Calculator !\[\]\(fe3aebe81acea8d45108cd2768939da7\_img.jpg\)](#)

$$ex \quad 100 = (11 \cdot 8kg/m^3) + 12$$

### 10) Minimum River Density given Relative Density

$$fx \quad \rho_{min} = -((H^2 \cdot \rho') - \rho_{max})$$

[Open Calculator !\[\]\(899d8b7697d64725bf017d3296cfcf1b\_img.jpg\)](#)

$$ex \quad 12 = -((11 \cdot 8kg/m^3) - 100)$$



### 11) Portion caused by Filling Evaluated by Comparing Tidal Prism of Harbor to Total Harbor Volume

$$\text{fx } \alpha_f = \frac{P}{V}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$\text{ex } 5 = \frac{32\text{m}^3}{6.4\text{m}^3}$$

### 12) Portion caused by Filling given Average Harbor Depth

$$\text{fx } \alpha_f = \frac{\Delta h}{h'}$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$\text{ex } 3.5 = \frac{21\text{m}}{6\text{m}}$$

### 13) Portion caused by Filling given Ratio of Water Volume Entering Harbor per Tide

$$\text{fx } \alpha_f = \alpha - \alpha_D$$

[Open Calculator !\[\]\(bd3b31712ad9bab5a241210fa6925cdd\_img.jpg\)](#)

$$\text{ex } 3.5 = 10 - 6.5$$


### 14) Ratio of Water Volume entering Harbor per Tide to Harbor Volume

$$\text{fx } \alpha = \alpha_f + \alpha_D$$

[Open Calculator !\[\]\(7bc43b319a082987e20f7bf78f4bab80\_img.jpg\)](#)

$$\text{ex } 10 = 3.5 + 6.5$$



15) Relative Density given River Density 

$$fx \quad H^2 = \frac{\rho_{\max} - \rho_{\min}}{\rho'}$$

Open Calculator 

$$ex \quad 11 = \frac{100 - 12}{8\text{kg/m}^3}$$

16) Relative Density given Velocity in Dry Bed Curve 

$$fx \quad H^2 = \frac{V_{Dbc}^2}{0.45 \cdot [g] \cdot d}$$

Open Calculator 

$$ex \quad 5.098581 = \frac{(4.5\text{m/s})^2}{0.45 \cdot [g] \cdot 0.9\text{m}}$$

17) Tidal Prism of Harbor Basin 

$$fx \quad P = \alpha_f \cdot V$$

Open Calculator 

$$ex \quad 22.4\text{m}^3 = 3.5 \cdot 6.4\text{m}^3$$

18) Tidal Prism of Harbor Basin given Difference between High and Low Tide Levels 

$$fx \quad P = V \cdot \left( \frac{\Delta h}{h'} \right)$$

Open Calculator 

$$ex \quad 22.4\text{m}^3 = 6.4\text{m}^3 \cdot \left( \frac{21\text{m}}{6\text{m}} \right)$$



### 19) Total Harbor Volume based upon Depth

[Open Calculator !\[\]\(feabb98897b440bc8695a03336a6e2df\_img.jpg\)](#)

$$fx \quad V = \frac{P}{\alpha_f}$$

$$ex \quad 9.142857m^3 = \frac{32m^3}{3.5}$$

### 20) Total Harbor Volume based upon Depth given difference between High and Low Tide Levels

[Open Calculator !\[\]\(642aa997563f9a325b310230bb5078b7\_img.jpg\)](#)

$$fx \quad V = \frac{P}{\frac{\Delta h}{h'}}$$

$$ex \quad 9.142857m^3 = \frac{32m^3}{\frac{21m}{6m}}$$

### 21) Total Water Volume Exchanged during entire Tide Period

[Open Calculator !\[\]\(51514032c8ca341817228f39f1307b05\_img.jpg\)](#)

$$fx \quad V_w = G \cdot A_E \cdot \sqrt{H^2 \cdot h'}$$

$$ex \quad 49.55663m^3/s = 0.1 \cdot 61m^2 \cdot \sqrt{11 \cdot 6m}$$

### 22) Velocity in Dry Bed Curve

[Open Calculator !\[\]\(f219cfc00b8db0cd1a81ae1fc9afaf28\_img.jpg\)](#)

$$fx \quad V_{Dbc} = 0.45 \cdot \sqrt{H^2 \cdot [g] \cdot d}$$


$$ex \quad 4.433947m/s = 0.45 \cdot \sqrt{11 \cdot [g] \cdot 0.9m}$$



23) Water Depth given Velocity in Dry Bed Curve [Open Calculator](#) 

$$\text{fx } d = \frac{\left(\frac{V_{\text{Dbc}}}{0.45}\right)^2}{H^2 \cdot [g]}$$

$$\text{ex } 0.927015\text{m} = \frac{\left(\frac{4.5\text{m/s}}{0.45}\right)^2}{11 \cdot [g]}$$

Density Influence 24) Density Influence [Open Calculator](#) 

$$\text{fx } \alpha_D = (V_D - V_f) \cdot \frac{T_D}{2 \cdot L}$$

$$\text{ex } 6.5 = (25\text{m/s} - 7\text{m/s}) \cdot \frac{130\text{s}}{2 \cdot 180\text{m}}$$

25) Filling Current Velocity given Density Influence [Open Calculator](#) 

$$\text{fx } V_f = -\left(\left(2 \cdot L \cdot \frac{\alpha_D}{T_D}\right) - V_D\right)$$

$$\text{ex } 7\text{m/s} = -\left(\left(2 \cdot 180\text{m} \cdot \frac{6.5}{130\text{s}}\right) - 25\text{m/s}\right)$$





## 26) Length of Harbor given Density Influence

[Open Calculator !\[\]\(666e09182d4cd268646ea700ea60dcdf\_img.jpg\)](#)

$$fx \quad L = (V_D - V_f) \cdot \frac{T_D}{2 \cdot \alpha_D}$$

$$ex \quad 180m = (25m/s - 7m/s) \cdot \frac{130s}{2 \cdot 6.5}$$

## 27) Time Interval over which Density Difference exists given Density Influence

[Open Calculator !\[\]\(003082e50e3009141f59bd5df831749f\_img.jpg\)](#)

$$fx \quad T_D = \frac{2 \cdot L \cdot \alpha_D}{V_D - V_f}$$

$$ex \quad 130s = \frac{2 \cdot 180m \cdot 6.5}{25m/s - 7m/s}$$










## Variables Used

- $A_E$  Cross Sectional Area of Entrance (*Square Meter*)
- $d$  Water Depth (*Meter*)
- $G$  Coefficient for Harbors
- $h'$  Average Harbor Depth (*Meter*)
- $H^2$  Broad Sense Heritability
- $L$  Length of Harbor (*Meter*)
- $P$  Tidal Prism Filling Bay (*Cubic Meter*)
- $T_D$  Time Interval (*Second*)
- $V$  Total Harbor Volume (*Cubic Meter*)
- $V_D$  Density Current Velocity (*Meter per Second*)
- $V_{Dbc}$  Velocity in Dry Bed Curve (*Meter per Second*)
- $V_f$  Filling Current Velocity (*Meter per Second*)
- $V_w$  Total Water Volume (*Cubic Meter per Second*)
- $\alpha$  Ratio of Water Volume
- $\alpha_D$  Density Influence
- $\alpha_f$  Portion caused by Filling
- $\Delta h$  Difference between High and Low Tide level (*Meter*)
- $\rho'$  Average River Density (*Kilogram per Cubic Meter*)
- $\rho_{max}$  Maximum River Density
- $\rho_{min}$  Minimum River Density



## Constants, Functions, Measurements used

- **Constant:** [g], 9.80665 Meter/Second<sup>2</sup>  
*Gravitational acceleration on Earth*
- **Function:** sqrt, sqrt(Number)  
*Square root function*
- **Measurement: Length** in Meter (m)  
*Length Unit Conversion* 
- **Measurement: Time** in Second (s)  
*Time Unit Conversion* 
- **Measurement: Volume** in Cubic Meter (m<sup>3</sup>)  
*Volume Unit Conversion* 
- **Measurement: Area** in Square Meter (m<sup>2</sup>)  
*Area Unit Conversion* 
- **Measurement: Speed** in Meter per Second (m/s)  
*Speed Unit Conversion* 
- **Measurement: Volumetric Flow Rate** in Cubic Meter per Second (m<sup>3</sup>/s)  
*Volumetric Flow Rate Unit Conversion* 
- **Measurement: Density** in Kilogram per Cubic Meter (kg/m<sup>3</sup>)  
*Density Unit Conversion* 



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