PE Civil Exam Review Guide: Water Resources & Environmental Depth
Preview Edition

Errata

(updated 6/28/2022)

This document will be updated regularly.

NOTE: When this book was published in 2019, the PE Civil exams were open book. This allowed students to bring outside materials into the exam, and our book was structured with this in mind. As of January 2, 2022, the PE Civil exam is now a computer-based test (CBT), meaning it is no longer open book and no additional materials may be brought into the exam. It is also organized differently now that it has become CBT. While the breadth and depth portions were once administered separately in the morning and afternoon, respectively, they are now integrated into the exam as a whole.

Any references to an open-book exam in the *PE Civil Exam Review Guide: Breadth* (1st edition) should now be ignored. For the most up-to-date information regarding changes to the PE Civil exams, please visit the NCEES site: https://ncees.org/engineering/pe/civil-cbt/.

Rest assured—we are working on an updated edition that will still contain the most essential content you need to prepare for the PE Civil exam while helping you navigate the NCEES *PE Civil Reference Handbook*. Watch for this comprehensive guide, which will be released in the fall of 2022!

CHAPTER 1: Analysis and Design

(1) p. 1-10. There are calculation errors in Example 1.7. The corrections appear below in red boxes.

Example 1.7: TSS Outflow

A well-mixed lake has inflow and outflow equal to 0.45 L/s. The inflow suspended solids (TSS) concentration is 14.5 mg/L, whereas the lake concentration is 9.4 mg/L. If the only process, other than flushing, through which TSS can leave the lake water column is settling, what is the rate at which TSS leaves the lake by settling in grams/day?

A. 181 g/day
B. 198 g/day
C. 230 g/day
D. 476 g/day

Solution

The rate at which TSS enters the lake is:

$Q\,C_I = (0.45\text{ L/s})\,(86{,}400\text{ s/day})\,(14.5\text{ mg/L}) = 563{,}760\text{ mg/day}$

The rate at which TSS exits the lake is:

$Q = C = (0.45\text{ L/s})\,(86{,}400\text{ s/day})\,(9.4\text{ mg/L}) = 365{,}472\text{ mg/day}$

Therefore, the difference is the rate of settling, which is:

$(563{,}760\text{ mg/day} - 365{,}472\text{ mg/day}) = 198{,}288\text{ mg/day}$.

Answer: B

(2) p. 1-20. There are calculation errors in Example 1.11. The corrections appear below in red boxes.

Solution

$Q = C_s B H^{3/2}$

The value of the spillway coefficient ($2.1\text{ m}^{1/2}/\text{s}$) indicates that the Horton equation should be used to solve the problem.

$Q = (2.1\text{ m}^{1/2}/\text{s})(10\text{ m})(0.92\text{ m})^{3/2}$

$Q = 18.5\text{ m}^3/\text{s}$

$Q = (18.5\text{ m}^3/\text{s})(35.315\text{ ft}^3/\text{m}^3) = 653.3\text{ ft}^3/\text{s}$

(3) p. 1-22. There are calculation errors in Example 1.12. The corrections appear below in red boxes.

Solution

$Q = CH_a^n$

Table 1.4 can be used to find C and n. The depth measurement in the converging section is used.

$Q = (16.0)(3.5)^{1.58} = 115.8\text{ cfs}$

$Q = (115.8\text{ cfs})/(1.55\text{ cfs/MGD}) = 74.4\text{ MGD}$

CHAPTER 2: Hydraulics—Closed Conduit

(1) p. 2-2: In the table of contents, add **2.4.2: Parallel** (p. 2-44) between **2.4.1: Series** and **2.4.3: Loops**.

(2) pp. 2-15 to 2-16: There are calculation errors in the solution to Example 2.3. The corrections appear below in red boxes.

$\dot{m} = Q\rho$ and $Q = vA$

$A = 0.25\pi D^2 = 0.25\pi(0.100 \text{ m})^2 = 0.0079 \text{ m}^2$

$Q = (2 \text{ m/s})(0.0079 \text{ m}^2) = 0.016 \text{ m}^3\text{/s}$

$\dot{m} = (0.016 \text{ m}^3\text{/s})(1{,}000 \text{ kg/m}^3) = 16.0 \text{ kg/s}$

$F_X = \dot{m}[v - v(\cos\theta)] + PA - (PA)(\cos\theta)$

$F_X = (16.0 \text{ kg/s})(2 \text{ m/s})(1 - \cos 45°) + (200 \times 10^3 \text{ Pa})(0.0079 \text{ m}^2)(1 - \cos 45°)$

$F_X = 472 \text{ N}$

$F_Y = \dot{m}(-v)(\sin\theta) - (PA)(\sin\theta)$

$F_Y = (16.0 \text{ kg/s})(-2 \text{ m/s})(\sin 45°) - (200 \times 10^3 \text{ Pa})(0.0079 \text{ m}^2)(\sin 45°)$

$F_Y = -1{,}140 \text{ N}$

(3) p. 2-23: In Equation 2-37 and the following "where" statement, change *D* to *d*.

(4) p. 2-30 – 2-31: In Example 2.11, several numbers need to be corrected. In the problem statement, change 40 m to 32 m, and 43 m to 34 m.

Example 2.11: Siphon Analysis

A 50-mm-diameter siphon tube is used to drain water from an elevated storage tank over a wall and into a tank at ground level. The water surface elevation in the lower tank is maintained at 30 m. What is the discharge (in m^3/s) into the lower tank when the water surface in the elevated tank is 32 m? Also, what is the absolute pressure (in kPa) in the tube at the apex if the top of the wall is 34 m? Ignore energy losses.

Multiple changes to the **solution** appear below in red boxes.

Gauge pressure is zero at the discharge point into the lower tank (3).

$h_{z1} = h_{z3} + h_{v3}$

32 m = 30 m + $v_3^2/2g$

(2 m)(2)(9.81 m/s²) = v_3^2

v_3^2 = 39.2

v_3 = 6.3 m/s

$Q = vA$ = (6.3 m/s)(π/4)(0.050 m)² = 0.012 m³/s

To find the absolute pressure at the apex of the siphon tube (2), an energy balance is required between the elevated tank surface (1) and the apex of the siphon tube (2).

$H_1 = H_2$

Again, gauge pressure and velocity are zero at the tank surface (1).

$h_{z1} = h_{z2} + h_{p2} + h_{v2}$

32 m = 34 m + $P_2/\rho g + v_2^2/2g$

$P_{2,gauge}/\rho g$ = (32 m − 34 m) − (6.3 m/s)²/(2 × 9.81 m/s²) = -4.0 m

$P_{2,gauge}$ = (-4.0 m)(1,000 kg/m³)(9.81 m/s²) = -39,240 N/m² = -39.2 kPa

$P_{2,abs} = P_{atm} + P_{2,gauge}$ = 101.3 kPa [redacted] + (-39.2 kPa) = 62.1 kPa

(5) pp. 2-34. There are calculation errors in the solution to Example 2.13. The corrections appear in red boxes below as well as the insertion of two extra steps appearing in red.

$$\frac{(100\ \text{kPa})}{(9.8\ \text{kN/m}^3)} + \frac{v_1^2}{2(9.81\ \text{m/s}^2)} + 0 = 0 + \frac{(9v_1)^2}{2(9.81\ \text{m/s}^2)} + 0$$

$$\frac{2(9.81\text{m/s}^2)(100\text{kPa})}{(9.8\ \text{kN/m}^3)} + v_1^2 = 81v_1^2$$

$$200.0\ \text{m}^2/\text{s}^2 = 80v_1^2$$

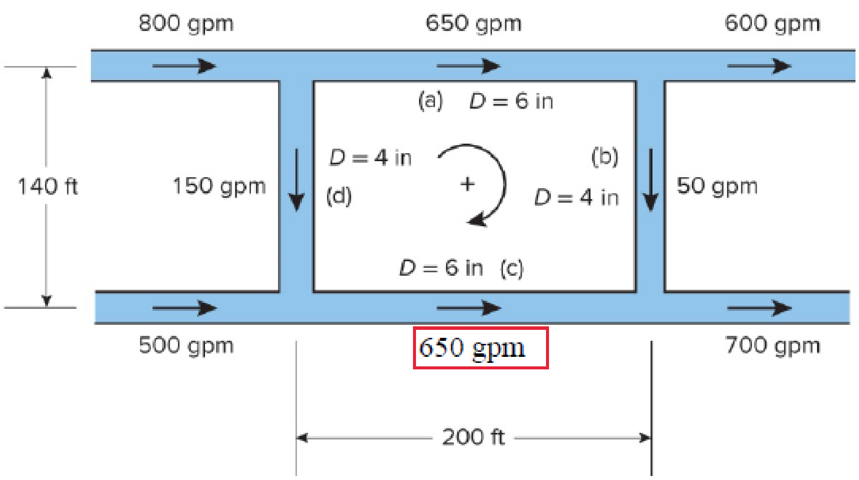
$v_1 = 1.58$ m/s

$Q = v_1A_1 = (1.58\ \text{m/s})(\pi/4)(0.075\ \text{m})^2(60\ \text{s/min})$

$Q = 0.42\ \text{m}^3/\text{min}$

(6) p. 2-44: A subheading is missing. After Example 2.17, add the subheading **2.4.2: Parallel**.

(7) p. 2-49: In the figure in Example 2.19, 150 gpm should be 650 gpm.



(8) pp. 2-49 to 2-50: There are calculation errors in the solution to Example 2.19. The corrections appear in red boxes below.

$h_{fc} = K_cQ_{ac}^{1.85} = -(6.76 \times 10^{-5})(650)^{1.85} = -10.8$ ft

$h_{fd} = K_dQ_{ad}^{1.85} = -(3.41 \times 10^{-4})(150)^{1.85} = -3.6$ ft

The algebraic sum of head losses around the pipe loop should equal zero. Step 6 in the Hardy-Cross procedure is summing the head losses calculated in the previous step.

$\Sigma h_f = 10.8 + 0.5 - \boxed{10.8} - 3.6 = \boxed{-3.1}$ ft

The resulting sum is not nearly zero, which tells us that more iterations are necessary to refine flow rate assumptions. Per step 7 of the Hardy-Cross procedure:

$|h_{fa} / Q_{aa}| = |10.8/650| = 0.017$

$|h_{fb} / Q_{ab}| = |0.5/50| = 0.010$

$|h_{fc} / Q_{ac}| = \boxed{|-10.8/650|} = \boxed{0.017}$

$|h_{fd} / Q_{ad}| = |-3.6/150| = 0.024$

$\Sigma|h_f / Q_a| = 0.017 + 0.010 + \boxed{0.017} + 0.024 = \boxed{0.068}$

Finally, the flow correction factor is calculated using Equation 2-80 (step 8).

$$\Delta Q = -\frac{\Sigma h_f}{n\Sigma|h_f/Q_a|} = -\frac{7.0}{1.85\boxed{(0.068)}} = -\boxed{56}\text{ gpm}$$

(9) p. 2-52: In the last line of the solution to Example 2.20, "gp" should read "gpm."

CHAPTER 3: Hydraulics—Open Channel

(1) p. 3-7: In the problem statement for Example 3.1, 20 cfs should be 60 cfs.

(2) p. 3-20: In the last line of the solution for Example 3.3, "criterion 2" should read "criterion 1."

(3) p. 3-21: In the solution to Example 3.4, there is an error. $AR^{2/3}$ = 4.98 should read $AR^{2/3}$ = 7.85.

(4) p. 3-22: The following text should be added at the end of the Example 3.5 problem statement:
Assume a Manning's coefficient of 0.05.

(5) p. 3-22: In the first sentence of Section 3.9.1.1.3, *y* should be *d*.

(6) p. 3-23: There are numbering errors in Section 3.9.2. Two references to Equation 3-28 should read Equation 3-30, and Figure 3.18 should read 3.21. See below for corrections.

Optimum channel dimensions for various cross-section shapes can be found using the equations in Table 3.5. A circle has the least wetted perimeter, *P*, for a given cross-section area, *A*, of any geometric shape. The most efficient circular cross section is a semicircle, which is the most efficient cross section of all. All cross sections that satisfy Equation 3-30 are such that a semicircle can be inscribed in them, as shown in Figure 3.21 The most efficient trapezoidal cross section is half of a hexagon. The most efficient rectangular cross section is half of a square.

Semicircular and circular shapes are practical for pipes, but earthen channels must be trapezoidal. The trapezoidal section determined from Equation 3-30 will be the most economical section to build as far as excavation and channel lining are concerned. Triangular (or v-shaped) channels are not very efficient, in general. The most efficient triangular section has a 90° vertex angle.

(7) pp. 3-28 – 3-29: In the problem statement for Example 3.9, "30-ft-wide" should read "32-ft-wide." In addition, the final answer should be 10.1 cfs (not 9.52 cfs).

(8) p. 3-30: There is a typographical error in Equation 3-40 (1 should be *i*). It should appear as: $E = \frac{Q_i}{Q} \times 100\%$.

(9) p. 3-36: In the fourth line of the solution to Example 3.11, 0.46 should be 1.34.

(10) p. 3-45: In Equation 3-57, replace *C* with C_d.

(11) p. 3-47: In Table 3.9, both instances of K_e should be k_e (lowercase *k*).

(12) p. 3-48: In Equation 3-66, K_c should be moved to the numerator. The equation should appear as follows:

$$H_L = k_e\left(\frac{v^2}{2g}\right) + \frac{K_c v^2 n^2 L}{R^{4/3}} + \frac{v^2}{2g} \qquad \textbf{Equation 3-66}$$

(13) p. 3-48: In the solution to Example 3.14, there are several errors. Please see the corrections below.

Replace $v = \sqrt{\frac{H_L}{\frac{1+k_e}{2g}+\frac{n^2 L}{K_C R^{4/3}}}}$ **with** $v = \sqrt{\frac{2gH_L}{1+k_e+\frac{K_C n^2 L}{R^{4/3}}}}$

Replace $v = \sqrt{\frac{2.0}{\frac{1+0.5}{2(32.2)}+\frac{(0.013)^2(50)}{(29)(0.75)^{4/3}}}}$ **with** $v = \sqrt{\frac{2(32.2)(2.0)}{1+0.5+\frac{29(0.013)^2(50)}{(0.75)^{4/3}}}}$

Replace $v = 9.2$ ft/s **with** $v = 8.3$ ft/s.

CHAPTER 4: Hydrology

(1) p. 4-11: There are corrections to some of the numbers in the solution for Example 4.3. These appear in red boxes below.

Example 4.3: Mean Areal Precipitation—Isohyets

Calculate the mean areal precipitation using the isohyetal map in Figure 4.7.

Solution

Starting with step 2, construct a table. In this case, because there is a significant portion of area to the right of the 1.0-in isohyet and to the left of the 2.0-in isohyet, the estimated isohyets at the edges of the watershed are included in the table (0.8 in and 2.1 in).

ISOHYET (in)	AVG. AREA BETWEEN ISOHYETS (sq)	AVG. ISOHYETS (in)	PRODUCT
0.8	–	–	–
	25	0.90	22.5
1.0	–	–	–
	111	1.25	138.8
1.5	–	–	–
	82	1.75	143.5
2.0	–	–	–
	11	2.05	22.6
2.1	–	–	–
Sum	**229**	–	**327.4**

The average area between isohyets is found by counting the colored squares. For example, there are approximately 111 blue squares between the 1.0-in and 1.5-in isohyets.

The second and fourth columns are summed and used in the equation for mean areal precipitation.

$$\overline{P} = \frac{\sum\left[A\left(\frac{P_1+P_2}{2}\right)\right]}{\sum A}$$

$$\overline{P} = \frac{327.4}{229} = 1.43 \text{ in}$$

(2) p. 4-15: In the solution to Example 4.5, the last line should start with E_p, and two additional lines (that should follow) are missing. This part should read:

$$E_p = \frac{(5.1 \text{ mm/day})}{(25.4 \text{ mm/in})} = 0.20 \text{ in/day}$$

$$E_r = K_p E_p$$

$$E_r = 0.70(0.20 \text{ in/day}) = 0.14 \text{ in/day}$$

(3) p. 4-16: In the "where" statement following Equation 4-9, *K* should read K_c.

(4) p. 4-18: Four numbers are incorrect in the solution to Example 4.6.

t (hr)	P_i (in/hr)	ϕ (in/hr)	Δ*t* (hr)	*Q* (in)
0	0.0	2.0	0.5	0.0
0.5	3.0	2.0	0.5	0.5
1	4.5	2.0	0.5	1.25
1.5	2.5	2.0	0.5	0.25
2	1.0	2.0	0.5	0.0
2.5	2.5	2.0	0.5	0.25
3	0.0	2.0	0.5	0.0
			Sum	**2.25**

$Q_{volume} = Q_{depth} \times \text{Area}$

$Q = (2.25 \text{ in})(300 \text{ ac})/(12 \text{ in/ft}) = 56.25 \text{ ac-ft}$

(5) pp. 4-26 – 4-27: There are some incorrect numbers in the solution to Example 4.7. Please see the corrections in red boxes below.

Solution
30 ac – 3 ac green space = 27 ac

15% of 27 ac = 4.05 ac

16 lots × 1/2 ac/lot = 8 ac (area draining directly to creek)

Remaining lot area = 27 ac – 8 ac – 4.05 ac = 14.95 ac

Weighted coefficient for area contributing to stormwater basin:

$$C_w = \frac{(0.25)(3\text{ ac})+(0.90)(4.05\text{ ac})+(0.40)(14.95\text{ ac})}{22\text{ ac}}$$

$C_w = 0.47$

CHAPTER 5: Groundwater and Wells

(1) p. 5-9: In the solution to Example 5.4, there are two corrected numbers, shown in red boxes below.

$Q = 451.2\ \text{ft}^3/\text{day}$

There are 192.5 ft^3/day in 1 gpm, therefore:

$Q = (451.2\ \text{ft}^3/\text{day}) / (192.5\ \text{ft}^3/\text{day} / \text{gpm}) = 2.3\ \text{gpm}$

CHAPTER 6: Wastewater Collection and Treatment

(1) Throughout chapter: The header of the pages throughout the chapter is incorrect. It should read "Wastewater Collection and Treatment" rather than "Water Quality."

(2) p. 6-14: In the where statement following Equation 6-7, the second instance of B_1 should instead read B_2 (B_2 = DO of seed control bottle after incubation).

(3) p. 6-17: In the solution to Example 6.2, the last line of part B should read:

$k_{15} = 0.40 \times 1.136^{(15\text{-}20)} = 0.21\ d^{-1}$ (0.21 instead of 0.021)

(4) p. 6-24: There are some typographical errors in near the top of the page in section F. Please see corrections in red below.

F. Volume of clarifier is V = Area × Depth = $(\pi/4)(40^2)(10)$ = 12,560 ft^3

12,560 ft^3 × 7.4805 gal/ft^3 = 93,955 gal

Detention time = V/Q = 93,955 gal/1,670,000 gpd × 24 hr/day = 1.35 hr

(5) p. 6-25: In the last line of the solution to Example 6.6, 39 ft should be 43.7 ~44 ft. The answer (C. 44 ft) is correct as is.

(6) p. 6-36: There are typographical errors in the problem statement for Example 6.13. See corrections in red below.

Example 6.13: Aeration Tank Volume

An 8-MGD wastewater treatment plant uses activated sludge for secondary treatment with the following specifications:

BOD_5 concentration after primary treatment = 154 mg/L
MLVSS concentration = 2,300 mg/L
F:M ratio = 0.25 per day

(7) p. 6-40: In the where statement following Equation 6-39, F = as previously defined in Equation 6-31 should read:

F = as previously defined in Equation 6-37.

(8) p. 6-51: The title above Equation 6-41 should read Aerobic digestor volume (not anaerobic).

(9) p. 6-53: In the solution to Example 6.21, the units for solids settled in the primary clarifier should be lb/day.

CHAPTER 7: Water Quality

(1) p. 7-9: In Table 7.3, add K^+ after Na^+.

MOLECULAR FORMAT	MOLECULAR WEIGHT	EQUIVALENT WEIGHT
	IONS IN WATER	
Na^+	23.0	23.0
K^+	39.1	39.1
Ca^{2+}	40.1	20.0

(2) p. 7-18: In the solution to Example 7.6, waste load allocation should appear as 92 kg (remove the rest of the line following 92 kg). Remove 92 kg from the margin of safety line. These two lines should appear as follows.

Waste load allocation = 92 kg ~~$= \frac{10}{100} \times 92 = 9.2$~~

Margin of safety (MOS) = 10% of WLA = ~~92 kg =~~ $\frac{10}{100} \times 92 = 9.2$

(3) p. 7-22: In the solution to Example 7.7, O_r should read Q_r. In addition, "Using Equation 6-51 (defined previously in chapter 6 of this book)" should read "Using Equation 7-9 (defined previously)."

(4) p. 7-22: In the solution to Example 7.8, "Equation 6-51 in chapter 6 of this book" should be changed to "Equation 7-9."

(5) p. 7-24: In the where statement at the top of the page, remove the last line (DO_{sat} = DO (at the point of discharge)). The previous line should read:

D_0 = dissolved oxygen deficit in the mixing zone (mg/L) = $DO_{sat} - DO$ (at the point of discharge)

CHAPTER 8: Drinking Water Distribution and Treatment

(1) p. 8-6: In the first line of section 8.1.2: Population Estimation Methods, "quality" should be "quantity."

(2) p. 8-27: In the solution to Example 8.7, remove "or setting." The sentence should read: The flocculation tank depth will be the same as the settling tank depth…

(3) p. 8-28: In the second paragraph of section 8.5: Sedimentation, **sone settling** should be **zone settling.**

(4) p. 8-40: There is a typographical error in Equation 8-31. (Replace ϵ with ε.) It should be:

Multisized: $D_e = D(1-\varepsilon)\sum \frac{f}{1-\varepsilon_e}$ **Equation 8-31**

In the following equation, replace α with ε. It should be:

$$\varepsilon_e = \left(\frac{v_B}{v_S}\right)^{0.2247 {N_R}^{0.1}}$$

(5) p. 8-41: In the fifth paragraph of section 8.6.3: Design Criteria, the units for 30 to 60 should be m/hr (not min/hr). Also, remove the phrase "per min" following 30 to 60 m/hr.

It should read: The backwash rate is 12 to 36 in/min (30 to 60 m/hr) rise rate, and…

(6) p. 8-41*:* In Example 8.13, the units listed for the clean bed filtering velocity in the problem statement and solution should be 4.6 m/hr (not min/hr).

(7) p. 8-43: In the last line of the problem statement for Example 8.16, *m* should instead read 0.25 m^3/s. The corrected version follows:

Given a design flow capacity of the water system of 0.25 m^3/s, how many filters should be installed?

(8) p. 8-43: In Equation 8-33, replace mq/L with meq/L.

(9) p. 8-61: Replace the last line in the problem statement for Example 8.28 with the following:

For the Freundlich model, the adsorption capacity, *K*, is 21 mg/g, and the slope is 0.54.

Throughout the solution, replace all instances of lowercase *k* with capital *K.*

CHAPTER 9: Engineering Economics Analysis

(1) p. 9-10. In Example 9.6, the second line of the question should read: "The maintence cost of the new truck is $1,000…". See corrections in red below.

Example 9.6: Uniform Gradient to Present Value

A city needs to purchase a new regenerative air vacuum truck for maintenance of its permeable pavement parking lots. The maintenance cost of the new truck is $1,000 in year one and is expected to increase by $200 per year for the next 4 years. What is the *PV* of the first 5 years of maintenance costs of the vacuum truck? Assume a 6% interest rate.

A. $1,587
B. $4,212
C. $5,799
D. $7,970

(2) p. 9-13: In Example 9.11, "$5,000" in the question and solution needs to be changed to "$10,000". See corrections in red below.

Example 9.11: Rate of Return

The state DOT stormwater engineer authorizes the installation of continuous monitoring and adaptive controls on ten existing stormwater detention basins. The project cost is $50,000 and has a 10-year useful life. These improvements save the DOT $10,000 per year in costs that would have been spent on other stormwater measures to meet watershed pollutant reduction goals. What is the approximate rate of return on the investment?

A. 5.0%
B. 10.0%
C. 15.0%
D. 20.0%

Solution

PV of benefits = *PV* of costs

$10,000(*P*/*A*, *i*, 10) = $50,000

(*P*/*A*, *i*, 10) = $50,000/$10,000 = 5.0

By searching the factor tables for (*P*/*A*, *i*, 10) = 5.0, we find that the *P*/*A* factor for *i* = 15% is very close to 5.0 (5.0188). Therefore, the rate of return for this investment is approximately 15%.

Answer: C