California Wastewater Formula Companion — Grades 1–5

Loadings & removals · conversions · the core formula set · wasting & digester math · gas & alkalinity · verified pass standards

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THE PASS STANDARD — EVERY GRADE

Every grade requires **70% or more overall AND 50% or more on the mathematics questions**. Grade I: 135 points in 2.5 hours (45 true/false × 1 pt + 25 multiple-choice × 2 pts + 10 math × 4 pts) — pass at 94.5 points overall and 20 math points. Grade II: 150 points in 2.5 hours — pass at 105 and 20. Grade III: 97 points in 3.5 hours — pass at 68 and 10. Grade IV: 128 points in 4 hours — pass at 90 and 15. Grade V: 140 points in 4 hours — pass at 98 and 16. Renewal is triennial, and California imposes no wastewater contact-hour requirement.

LOADINGS, REMOVALS & EFFLUENT STANDARDS

Item	Reference
Organic loading rate	lb/day of BOD or suspended solids applied to a treatment unit (per volume or area, as specified)
Primary clarifier removal	removes half to two-thirds of the suspended solids and about a third of the BOD of raw wastewater (settling alone)
Food-to-microorganism (F/M) ratio	lb of BOD applied per day ÷ lb of MLVSS under aeration — for conventional activated sludge, typically 0.2–0.5 lb BOD/day per lb MLVSS
F/M low value effect	the biomass has too little food, so organisms consume their own mass (endogenous phase) and effluent quality generally improves — unless excessive endogenous respiration creates pin floc

Item	Reference
Surface overflow rate	SOR = flow ÷ clarifier surface area — e.g., 500 gpm over 2,500 ft² = 0.2 gpm/ft²
Weir loading rate	weir loading rate = flow ÷ weir length (gpd/ft) — e.g., 1.2 MGD over a 250-ft weir = 4,800 gpd/ft
Effluent secondary standards (CBOD5 / TSS)	30-day average 25 mg/L / 30 mg/L; 7-day average 40 mg/L / 45 mg/L; at least 85% removal of influent CBOD5 and TSS
Effluent pH	not less than 6.0 and not greater than 9.0 at any time; weir rates are limited so upward velocities cannot lift settled solids into the effluent launder

CONVERSIONS & CONSTANTS

Item	Value
Weight of water	8.34 lb per gallon
Cubic foot of water	7.48 gal and 62.4 lb
MGD to cfs	1 MGD = 1.547 cubic feet per second
MGD to gpm	1 MGD = 694 gpm
Acre-foot	325,829 gallons
Pressure head	1 psi = 2.31 feet of water

THE CORE FORMULA SET

Formula	Form
Pounds formula	lb/day = flow (MGD) × concentration (mg/L) × 8.34
Detention time	tank volume ÷ flow rate (matching units) — e.g., 0.5 MG ÷ 2.0 MGD = 0.25 day = 6 hours
F/M ratio	lb BOD/day applied ÷ lb MLVSS under aeration (both from the pounds formula); volumetric loading = (lb/day BOD ÷ basin volume in ft³) × 1,000, in lb BOD/day per 1,000 ft³
Sludge volume index (SVI)	(settled volume in mL/L after 30 min × 1,000) ÷ MLSS in mg/L — e.g., (300 × 1,000) ÷ 2,500 = 120 mL/g, within the typical 50–150 mL/g range; sludge density index SDI = 100 ÷ SVI; solids under aeration: lb MLSS = basin volume (MG) × MLSS (mg/L) × 8.34

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Mean cell residence time (MCRT)	total suspended solids in the system (lb) ÷ total solids leaving per day (lb in waste sludge + lb in effluent)

WASTING, RETURN & DIGESTER LOADING

Item	Reference
Waste flow for a target wasting rate	waste lb/day ÷ (waste concentration in mg/L × 8.34) = MGD wasted — e.g., 1,200 ÷ (6,000 × 8.34) = 0.024 MGD
Return activated sludge (RAS) rate	28–32 inches on the blanket-depth gauge during peak flow (target blanket: 12–18 in. off-peak; 18–24 in. normal flow)
Digester volatile-solids loading	lb VS fed per day ÷ digester volume in ft³ — e.g., 4,250 lb/day over 85,000 ft³ = 0.05 lb VS/day/ft³, within the typical 0.04–0.10 range
Volatile-solids reduction	VS reduction % = (VS in − VS out) ÷ VS in × 100 — e.g., 1,000 → 450 lb = 55%
Sludge pumping volume	gal/day = pumping rate (gpm) × pumping time (min/day) — e.g., 150 gpm × 180 min = 27,000 gal/day; pounds wasted = gal (in MG) × mg/L × 8.34

GAS, HEAT & ALKALINITY

Item	Reference
Gas production rate	ft³ of gas per lb of volatile solids destroyed — e.g., 12,000 ft³ ÷ 800 lb = 15 ft³/lb VS destroyed
Methane fraction	healthy digester gas runs about 60–70% methane; methane content is the best single indicator of digester health
Heat value of digester gas	about 600 BTU per ft³ at roughly 65% methane (heat value rises with methane fraction)
Nitrification alkalinity demand	7.14 mg of alkalinity (as $CaCO_3$) consumed per mg of ammonia-nitrogen nitrified
Residual alkalinity target	about 50–100 mg/L as $CaCO_3$ remaining in the effluent to buffer pH during nitrification
Filamentous bulking remedy (RAS chlorination)	typical starting range 2–3 lb Cl_2 per day per 1,000 lb MLSS — correct bulking by identifying the cause; the RAS chlorination dose is lb/day = (lb per 1,000 lb MLSS × MLSS in lb) ÷ 1,000. Typical activated-sludge MLSS is 1,500–3,000 mg/L

READING THIS SHEET BY GRADE

Scope by grade	Grade I covers the foundations above (pounds formula, detention time, overflow and weir rates, conversions, primary removals). Secondary-process math (F/M, SVI, MCRT) enters at Grade II; wasting/MLVSS and digester volatile-solids loading at Grade III; gas/heat-value and nitrification alkalinity at Grade IV; methane fraction and residual alkalinity at Grade V.

WHAT THIS SHEET DOESN'T COVER

- Process-control judgment: diagnosing upsets and choosing operational responses as scenarios.
- Blueprint-weighted scenario application across each grade's exam content outline.
- Timed, full-length exam simulation for your grade.
- An explanation for every answer — why the right answers are right and the wrong ones are wrong.
- A fresh set of questions on every attempt, so practice never repeats itself.

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Reference values: the State Water Resources Control Board Wastewater Operator Certification Program examination information sheets (format and pass standards) and the formulas used across the PassProfessor California Wastewater question banks' worked explanations.