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COUNTY OF VENTURA

ENVIRONMENTAL HEALTH DIVISION

M E M O R A N D U M

TO: Dennis Hawkins
Planning

DATE: December 19, 1995

FROM: Darrell Siegrist

SUBJECT: **PROCEDURES FOR ASSESSING AREAWIDE IMPACTS TO GROUNDWATER QUALITY RESULTING FROM SEPTIC SYSTEM - GENERATED NITRATES**

The North Coast and Santa Ana Regional Water Quality Control Boards have used a mass-balance analysis method to indicate the long-term equilibrium value of nitrate in the immediate vicinity of septic systems and to serve as a basis for quantifying possible areawide impacts. It is this Division's understanding that this method has been used by these public agencies for making land use decisions. We are, therefore, recommending its use in analysis of the potential impacts to the Santa Rosa Valley Groundwater Basin caused by the proposed use of septic systems contained in the Nicholson and Las Robles Bank General Plan Amendments.

The mass-balance analysis involves the following calculations:

1. Nitrate concentration in the total percolate (N_{TP})

$$N_{TP} = \frac{(N_{WW})\ (WW_L)\ +\ (N_{DP})\ (DP)}{(WW_L\ +\ DP)}$$

Where:

N_{tp}	=	Nitrate - N in the total percolate	(mg/l)
N_{ww}	=	Nitrate - N in the wastewater	(mg/l)
WW_L	=	wastewater loading	(in/yr)
N_{DP}	=	Nitrate - N in the deep percolate	(mg/l)
DP	=	deep percolate	(in/yr)

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To accurately determine the appropriate values used in the above calculation, the following information should be considered by the EIR consultant:

a) Daily water consumption per lot for:

1. Domestic use.
2. Landscape irrigation.
3. Animal Husbandry.

b) Soil type (to determine appropriate denitrification factor).

c) Nitrogen present in domestic effluent (prior to treatment in septic system) expressed as grams/capita/day.

d) Quantification of deep percolate.

e) Quantification of nitrate concentration in deep percolate.

2. Determination of Critical Development Density (D_c)

$$D_C = \frac{(2.01)\ (N_{ww} - 10)}{(DP)\ \ (10 - N_{DP})}$$

Where:

D_C = Critical development density in acres per dwelling unit

N_{WW} = Nitrate - N in the wastewater adjusted for denitrification losses (mg/l)

DP = Deep percolate (in/yr)

N_{DP} = Nitrate - N of the deep percolate (mg/l)

The above formulae provide for analysis of potential nitrate contamination attributable to the projects as proposed (formula 1) and identification of the maximum septic system density which is not anticipated to result in groundwater contamination in excess of the State maximum contaminate level for nitrate (formula 2). Project analysis using these formulae will, therefore, facilitate project environmental impact determination and may prove useful in development of possible mitigation measures should the impact determination indicate a significant degree of impact.

These formulae have been provided to the Public Works Agency for their review and comment. Please call me at extension 2811 if you have any questions, or would like further information pertaining to application of these formulae.

c: Lowell Preston, Public Works Agency
Robert Gallagher, Environmental Health Division

COUNTY OF VENTURA

ENVIRONMENTAL HEALTH DIVISION

M E M O R A N D U M

TO: Lowell Preston
Water Resources Division
Public Works Agency

DATE: February 7, 1996

FROM: Robert Gallagher RG

SUBJECT: MODEL FOR DETERMINING NITRATE LOADING FROM SEPTIC SYSTEMS

Attachment 1 contains information pertaining to a model that can be used to determine the potential impacts to groundwater quality from proposed development projects relying on septic systems for wastewater disposal. This model was presented to the North Coast Regional Water Quality Control Board by Ramlit Associates in a report titled "Assessment of Cumulative Impacts of Individual Waste Treatment and Disposal Systems" (February 1982) and has been applied by the Santa Ana Regional Water Quality Control Board since approximately 1989.

Studies by the Santa Ana Regional Water Quality Control Board, the North Coast Regional Water Quality Control Board, and many others have shown that the density of septic systems in an area is an important parameter affecting the total nitrate concentration that reaches groundwater.

By applying the model described in Attachment 1, an optimum septic system density can be determined for a specific area. Proposed projects exceeding this density will potentially add nitrates to the groundwater at concentrations greater than State Drinking Water Standards and State Water Quality Control Board groundwater quality objectives.

Attachment 2 is an application of the model for the Santa Rosa Valley. The optimum density identified is 2.875 acres per septic system.

Please note, the 2.875 acres per septic system density should not be considered an absolute number. Rather, it should be considered the number that was derived based on the best information readily available to staff. Some of the values used in the model were based on either national averages or data obtained from the Santa Ana Regional Water Quality Control Board and may not accurately depict local conditions. It is possible through additional analysis to more precisely identify values, such as deep percolate, for the Santa Rosa Valley which could affect the model outcome. Thus, the model presented should not be considered or used as a precise tool, but rather as a method to reasonably estimate nitrate outcomes from residential septic system densities.

Please call me at 654-2821, if you have any questions.

RG/jm/gallaghe/ntraload.pre

Attachments (2)

c: Tom Berg
Don Koepp

4 bdrms main hse } = 6 peo per Co. Water Works Manual
1 " guest hse. }

MODEL FOR DETERMINING NITRATE LOADING FROM SEPTIC SYSTEMS

$$N_{TP} = \frac{(N_{WW})(WW_L)+(N_{DP})(DP)}{(WW_L+DP)}$$

where:
- N_{TP} = nitrate -N in total percolate, expressed as milligrams/liter (mg/l)
- N_{WW} = nitrate -N in wastewater percolate adjusted for denitrification losses, expressed as milligrams/liter (mg/l)
- WW_L = wastewater loading, expressed as inches/year (in/yr)
- N_{DP} = nitrate -N in the deep percolate, expressed as milligrams/liter (mg/l)
- DP = deep percolate, expressed as inches/year (in/yr)

Any set of values use in the model that would result in N_{TP} being greater than 10.0 mg/l nitrate-N is considered to have a potential to adversely impact groundwater quality. The following is a discussion of the equations used to determine N_{TP}:

Equation 1:

$$N_{WW} = \frac{\text{(total nitrogen concentration per capita per day) (denitrification factor)}}{\text{average daily wastewater flow per capita}} \times 1000\text{mg/g}$$

22.6 g/day is high average → national average is 14.5 g/day →

a) Total nitrogen concentration = 12 grams per person per day (gms/c/d). 12 gms/c/d represents the midrange value for mass loading per capita in a household with a garbage grinder. (Source: U.S.E.P.A. Manual - On-site Wastewater Treatment and Disposal Systems, 1980)

b) Denitrification factor -.85, .70, or .60. (for sands → .85; average soil → .70; = for clays → .60)

The denitrification factor is determined by combining the anticipated denitrification of 15% which occurs in septic tanks (Source: Andreoli, A., et al, Nitrogen Removal in a Subsurface Disposal System, 1979) with the denitrification of either 0%, 15%, or 25% which occurs in sand, loam, or clay soils respectively (Source: Ramlit Associates, 1982). Thus, for loam soils, the total denitrification factor would be 100%-(15%+15%) = 70%, or .70.

c) Average daily wastewater flow per capita is determined by dividing the average daily wastewater flow from a household by the average population per dwelling unit. According to the U.S.E.P.A. Manual (1980), the national average daily wastewater flow per capita is 50 gallons. Local deviations from this flow rate can be identified through use of local water purveyor

T.O. average daily water use per horse is 477 gal/day
" " wastewater " " 285.68 gal/day

information and census data. For example, in the Santa Rosa Valley, daily household wastewater flows were estimated by the Camrosa Water District to be 211 gallons; according to the Planning Division census data, there is an average of 3.67 persons per dwelling unit in that area. Thus, average daily wastewater flow per capita in the Santa Rosa Valley is 57.5 gallons.

convert to liters (3.785 l/gal)

Equation 2: $$WW_L = \frac{\text{wastewater flow per dwelling}}{\text{lot size}} \ x \ 12 \text{ inches/foot}$$

a) Wastewater flow per dwelling averages between 150 gallons per day to 360 gallons per day (Source: U.S.E.P.A. Manual, 1980). As noted above, local water purveyor information can be used to more accurately estimate wastewater flows in a given area.

In this equation, gallons per day must be converted to inches per year.

Equation 3: 3.25 inches/year

In the Santa Ana Region, it was determined the majority, if not all, of the deep percolate is from precipitation. The average annual rainfall in this region is 14.4 inches and the average annual deep percolate is 3.25 inches (Source: Santa Ana R.W.Q.C.B.). The Santa Ana R.W.Q.C.B. reported a historical relationship between precipitation rate and deep percolation. Thus, for development projects proposed in the eastern portion of Ventura County, it is presumed the average annual deep percolate will be very similar to the deep percolate in the Santa Ana Reagion (3.25 inches) because the average rainfall in these two areas is also very similar (14-16 inches per year). However, additional analysis could result in a more accurate determination of deep percolate in an area. For example, comparison of development factors, such as the percentage of land area covered by paving and buildings, has not been made between the Santa Ana Region and Ventura County. Should development factors vary between these two areas, it is possible the runoff percentage and the actual evapotranspiration rates may also vary which could affect the calculation of deep percolate.

T.O. has 16.43"/yr. of precipitation on average

Equation 4: N_{DP} = amount of nitrate contained in rainfall, which is estimated to be 1 mg/l nitrate -N (Source: Santa Ana R.W.Q.C.B., Ramlit Associates, 1982).

OK

APPLICATION OF THE MODEL $N_{TP} = \frac{(N_{WW})(WW_L)+(N_{DP})(DP)}{(WW_L + DP)}$ FOR THE SANTA ROSA VALLEY

The following values are used to achieve a result of ≤10mg/l

nitrate -N for the model $N_{TP} = \frac{(N_{WW})(WW_L) + (N_{DP})(DP)}{(WW_L + DP)}$

- $N_{WW} = \frac{\text{(nitrate concentration in septic tank)(denitrification factor)}}{\text{average daily wastewater flow per capita}} \times 1000\text{mg/g}$

  nitrate concentration in septic tank = 12 gms/c/d
  denitrification factor = 100% - (15% reduction in septic tank - 15% reduction in loam soils) = 70%
  average wastewater flow = 57.5 gallons (218 liters) per capita [3.785 l/gal]

  $N_{WW} = \frac{(12\text{gms/c/d})(.70)}{218\ \text{l/c/d}} \times 1000\ \text{mg/g}$

  N_{WW} = **38.53 mg/l**

- $WW_L = \frac{\text{wastewater flow per dwelling}}{\text{lot size}} \times 12\ \text{inches/foot}$ [43,560 sq ft/acre]

  wastewater flow per dwelling = 10,296 cubic feet per year (211 gallons/day)
  lot size = 125,235 square feet (2.875 acres) [7.481 gal/cu ft.]

- **WW_L = .99 inches per year**

- **N_{DP} = 1 mg/l**

- **DP = 3.25 inches/year**

- $N_{TP} = \frac{(38.53\ \text{mg/l})(.99\ \text{in/yr}) + (1\ \text{mg/l})(3.25\ \text{in/yr})}{(.99\ \text{in/yr} + 3.25\ \text{in/yr})}$

  N_{TP} = 9.76 mg/l nitrate -N

SEPTIC SYSTEM POLICY

for

PROJECT REVIEWS

Discretionary Permits, Planned Developments, Conditional Use Permits, etc. within the following areas or unconfined groundwater basins must adhere to the established "Nitrate Formula" used to evaluate septic system impacts on groundwater supplies:

1. Upper Ojai
2. Piru Basin
3. Fillmore Basin
4. Oxnard Plain Forebay
5. Santa Rosa Valley
6. Upper Ventura River Basin
7. North Las Posas Outcrop area

Use the Quick-Reference table below to determine the project specific finding, and apply the indicated mitigation measure or project review finding to the written response;

LOCATION	PROJECT FINDING	MITIGATION MEASURE
Unconfined Basin (Known Nitrate Problem)	Significant (S) Apply Nitrate Formula	Install Package Treatment Plant, or Connect to Municipal Sewage System (site-specific application)
Unconfined Basin (No Known Nitrate Problem)	Less-Than-Significant (LS)	None
Confined Groundwater Basin	Less-Than-Significant (LS)	None

5.2.5 Other Assumptions

The following additional assumptions have been made for the calculations of total percolate concentration:

1. Uniform and complete mixing of wastewater and deep percolate in time and space

2. Full conversion of all forms of nitrogen to nitrate

3. Negligible lateral flow of wastewater

5.2.6 Nitrate-N Concentration in the Total Percolate, N_{tp}

$$N_{tp} = \frac{(N_{ww})\ (WW_L)\ +\ (N_{DP})\ (DP)}{(WW_L+DP)} \qquad (1)$$

If we assume that:

N_{ww} = 17.74 mg/l (75 gpcd wastewater flow; 0% denitrification (sec. 5.2.1))

WW_L = 12.5 in/yr (150 gal/day wastewater flow; 7,000 sq. foot lot size (sec. 5.2.2))

N_{DP} = 1.0 mg/l (sec 5.2.4)

DP = 3.25 in/yr (sec 5.2.3)

$$\text{Then Ntp} = \frac{(17.74)\ (12.5)\ +\ (1.0)\ (3.25)}{(12.5\ +\ 3.25)} = 14.29 \text{ mg/l}$$

As discussed previously and shown in Table 9, the wastewater loading rate (WW_L) is affected significantly by lot size as well as wastewater flow. If we assume a 20,000 sq. foot lot size, rather than 7,000 sq. foot as above, the resultant value for WW_L is 4.4 in/yr (see sec. 5.2.2). This change in WW_L in turn significantly affects N_{tp}:

$$\text{Ntp} = \frac{(17.74)\ (4.4)\ +\ (1.0)\ (3.25)}{(4.4\ +\ 3.25)} = 10.63 \text{ mg/l}$$

Thus, for a 20,000 sq-foot lot, and for the values assumed above, the nitrate-N concentration of the total percolate is very close to the drinking water action level of 10 mg/l.

Table 9 shows the results for N_{tp} based on different assumptions of lot size and wastewater flow. It is evident that lot size, or the density of development, is a critical factor in determining the impacts to ground water quality of septic systems.

As shown in preceding sections, there is a range of possible values for the variables in Equation 1. Figure 5 represents graphically the solutions of Equation 1 using a range of values for denitrification (this affects N_{ww} (see Table 8)) and wastewater loading rates (WW_L) (see Table 9). These graphical solutions provide useful information to evaluate water quality impacts from septic systems. It is clear from the graphical plots that the greatest potential for ground water nitrate problems arises in areas where the ratio of wastewater to deep percolation is high (i.e. areas of low rainfall and high density developments on septic systems). It is clear that, for high density developments, the 10 mg/l nitrate-N limit can be easily exceeded. Again, this demonstrates that the density of development is a critical factor in determining septic system impacts on ground water.

5.3 Nitrate Concentration in Ground Water

The septic system effluent and the recharge waters (total percolate) migrate through the soil into the underlying ground water. Let us examine the impact of the total percolate on ground water quality under various scenarios:

<u>Scenario 1.</u> Small lots, N_{tp} greater than 10 mg/l; ground water nitrate-N greater than 10 mg/l

For ground water subbasins with no assimilative capacity and where the nitrate concentration already exceeds the drinking water action level, high density developments on small lots (N_{tp} greater than 10 mg/l, see sec 5.2.6) will add to the nitrate problem.

<u>Scenario 2.</u> Small lots, N_{tp} greater than 10 mg/l; ground water nitrate-N less than 10 mg/l

If the ground water nitrate levels are lower than that of the total percolate, dilution of the total percolate by ground water can be expected. Due to the slow mixing of the percolate with ground water (laminar flow regime), most of the percolate will be confined to the upper portions of the aquifer. In this case, the percolate will slowly degrade the existing ground water quality.

<u>Scenario 3.</u> **Large lots, N_{tp} less than or equal to 10 mg/l; ground water nitrate-N greater than 10 mg/l**

On the contrary, the percolate from developments on large lots (N_{tp} less than 10 mg/l, see Sec. 5.2.6) will not cause a further violation of the drinking water action levels. The ground water quality will gradually improve.

<u>Scenario 4.</u> **Large lots, N_{tp} less than or equal to 10 mg/l; ground water nitrate-N less than 10 mg/l**

There will be no violation of the drinking water action level. Thus, the critical development density (see Sec. 5.4) is the most important factor in controlling nitrate loading to ground water.

Ntp Vs. WWL/DP

for Ndp = 1.0 mg/l