

# Ventura County Water Quality Index

## Technical Report

Bram Sercu

County of Ventura  
Watershed Protection District  
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## Description

The Ventura County Water Quality Index mathematically combines a number of variables, based on a large set of monitoring data, in one easily understood value. It was developed specifically for the County of Ventura to summarize chemical, microbiological and toxicity monitoring data, and is based on the Alberta River Water Quality Index (<http://environment.alberta.ca/01275.html>) and the CCME Water Quality Index<sup>1</sup>. The Index provides a simple snapshot of annual water quality conditions in the main rivers of the County.

## Methodology

The Ventura County Water Quality Index is calculated annually for each watershed, for dry and wet weather separately, based on the average of six sub-indices calculated for six variable groups:

- Salts
- Bacteria
- Nutrients
- Organics (includes pesticides)
- Metals
- Toxicity

The constituents included in the index were selected based on their relevance to river water quality. They include almost all constituents that have exceeded water quality objectives since 2004 in the County of Ventura receiving waters (excluding a few that correlate with other constituents) and all pesticides that were detected by the MS4 outfall monitoring program (often these do not have water quality objectives). Toxicity test results are included in the toxicity variable group.

Most chemistry and microbiology variables are currently measured once per year during dry weather and three times per year during storm events. Toxicity is currently measured for the first wet event per year (seasonal first flush).

The constituents included in the Ventura County Water Quality Index are summarized in Table 1, together with the water quality objectives or other environmentally relevant although not enforceable thresholds applicable during dry and wet weather.

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<sup>1</sup> Canadian Council of Ministers of the Environment (2001). Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, Technical Report, [http://www.ccme.ca/assets/pdf/wqi\\_techrprtftsht\\_e.pdf](http://www.ccme.ca/assets/pdf/wqi_techrprtftsht_e.pdf) (accessed on February 21, 2013).

**Table 1. Constituents included in the Ventura County Water Quality Index and applicable water quality objectives or other thresholds.**

| Constituents           | Units      | Threshold dry | Threshold wet | Threshold reference   |
|------------------------|------------|---------------|---------------|---|
| <b>Salts</b>           |            |               |               |   |
| Total Dissolved Solids | mg/l       | SSO           | SSO           | WQO   |
| Chloride               | mg/l       | SSO           | SSO           | WQO   |
| <b>Organics</b>        |            |               |               |   |
| 2,4,5-T                | ug/l       | 70            | n/a           | US EPA IRIS Reference Dose                                  |
| 2,4-D                  | ug/l       | 70            | 70            | WQO   |
| 2,4-DB                 | ug/l       | 56            | n/a           | US EPA IRIS Reference Dose                                  |
| 4,4'-DDE               | ug/l       | 0.00059       | n/a           | WQO   |
| 4,4'-DDT               | ug/l       | 0.00059       | 1.1           | WQO   |
| Aldrin                 | ug/l       | 0.00013       | 3             | WQO   |
| Azinphos methyl        | ug/l       | 0.01          | 0.01          | US EPA National Recommended Water Quality Criteria          |
| Bromacil               | ug/l       | 70            | n/a           | US EPA Drinking Water Health Advisory                       |
| Chlorpyrifos           | ug/l       | 0.014         | 0.02          | CA Department of Fish and Game Recommended criterion        |
| Dalapon                | ug/l       | 200           | n/a           | Drinking water MCL  |
| DCPA (Dacthal)         | ug/l       | 0.008         | 14300         | US EPA IRIS Reference Dose                                  |
| delta-BHC              | ug/l       | 500           | n/a           | National Academy of Sciences Drinking Water Health Advisory |
| Demeton-O              | ug/l       | 0.1           | n/a           | US EPA National Recommended Water Quality Criteria          |
| Demeton-S              | ug/l       | 0.1           | n/a           | US EPA National Recommended Water Quality Criteria          |
| Diazinon               | ug/l       | 0.05          | 0.08          | CA Department of Fish and Game Recommended criterion        |
| Dicamba                | ug/l       | 210           | n/a           | US EPA IRIS Reference Dose                                  |
| Dimethoate             | ug/l       | 1             | n/a           | CA DPH Drinking Water Notification Level                    |
| Diphenamid             | ug/l       | 200           | n/a           | CA DPH Drinking Water Notification Level                    |
| Glyphosate             | ug/l       | 700           | 700           | WQO   |
| Malathion              | ug/l       | 0.1           | 0.1           | US EPA National Recommended Water Quality Criteria          |
| Metolachlor            | ug/l       | 44            | 100           | US EPA Drinking Water Health Advisory                       |
| Pentachlorophenol      | ug/l       | 1             | 1             | WQO   |
| Simazine               | ug/l       | 4             | 4             | WQO   |
| Toxaphene              | ug/l       | 0.00073       | 0.73          | WQO   |
| Benzo(a)pyrene         | ug/l       | 0.0044        | 0.2           | WQO   |
| Chrysene               | ug/l       | 0.0044        | n/a           | WQO   |
| DEHP                   | ug/l       | 1.8           | 4             | WQO   |
| DEP                    | ug/l       | 23000         | n/a           | WQO   |
| <b>Bacteria</b>        |            |               |               |   |
| <i>E. coli</i>         | MPN/100 ml | 235           | 235           | WQO   |
| <b>Nutrients</b>       |            |               |               |   |
| DO                     | mg/L       | 5             | 5             | WQO   |
| pH                     | pH units   | 6.5-8.5       | 6.5-8.6       | WQO   |

|                     |      |      |      |              |
|---------------------|------|------|------|--------------|
| Nitrate-N           | mg/l | 10   | 10   | WQO          |
| Ammonia-N           | mg/l | calc | calc | WQO          |
| MBAS                | mg/l | 0.5  | 0.5  | WQO          |
| <b>Metals</b>       |      |      |      |              |
| Aluminum, total     | ug/l | 1000 | 1000 | WQO          |
| Antimony, total     | ug/l | 6    | 6    | WQO          |
| Arsenic, total      | ug/l | 50   | 50   | WQO          |
| Barium, total       | ug/l | 1000 | 1000 | WQO          |
| Beryllium, total    | ug/l | 4    | 4    | WQO          |
| Cadmium, total      | ug/l | 5    | 5    | WQO          |
| Cadmium, dissolved  | ug/l | calc | calc | WQO          |
| Chromium, total     | ug/l | 50   | 50   | WQO          |
| Chromium, VI        | ug/l | calc | calc | WQO          |
| Copper, dissolved   | ug/l | calc | calc | WQO          |
| Lead, dissolved     | ug/l | calc | calc | WQO          |
| Mercury, total      | ug/l | 0.05 | 2    | WQO          |
| Nickel, total       | ug/l | 100  | 100  | WQO          |
| Nickel, dissolved   | ug/l | calc | calc | WQO          |
| Selenium, total     | ug/l | 5    | 50   | WQO          |
| Silver, dissolved   | ug/l | calc | calc | WQO          |
| Thallium, total     | ug/l | 2    | 2    | WQO          |
| Thallium, dissolved | ug/l | 1.7  | n/a  | WQO          |
| Zinc, dissolved     | ug/l | calc | calc | WQO          |
| <b>Toxicity</b>     |      |      |      |              |
| IC50                | %    | 100  | 100  | NPDES permit |

**Notes** SSO: site-specific objectives, n/a: not applicable, calc: threshold calculated based on other water quality parameters, WQO: water quality objective

The mathematical formula used to calculate the individual sub-indices is the same one as used by the province of Alberta, Canada (Appendix). However due to unique aspects in climate, pollutants of concern, urbanization, monitoring programs and environmental regulations that apply to the County of Ventura, compiling of the overall Index is tailored to Ventura County.

The Index formula is based on three aspects of water quality that relate to water quality objectives:

- Scope (F1): how many constituents do not meet objectives?
- Frequency (F2): how frequently do measurements not meet objectives?
- Magnitude (F3): by how much do measurements not meet objectives?

Most constituent concentrations are compared to the applicable water quality objectives, as explained in the Ventura Countywide Stormwater Quality Management Program 2011/2012 Water Quality Monitoring Report. For some pesticides water quality objectives have not been adopted by the State Water Resources Control Board. In those cases, the most stringent thresholds available from the State Water Resources Control Board's Water Quality Goals website were used

([http://waterboards.ca.gov/water\\_issues/programs/water\\_quality\\_goals/search.shtml](http://waterboards.ca.gov/water_issues/programs/water_quality_goals/search.shtml)). Note that the calculations for constituents without water quality objectives is slightly different, as explained below, in order to reflect the priorities of the State Water Resources Control Board.

Index values are calculated annually for the six variable groups for each watershed, and separately for dry and wet weather events. The latter is important because water quality and pollutants of concern are often different during dry and wet weather, as our Mediterranean climate hardly produces rain between May and September. The sub-indices are then averaged to produce an overall River Water Quality Index for dry and wet weather events. Multiple indices can also be averaged to obtain an index for all watersheds combined, or for dry and wet weather combined, as shown in Table 2 (for 2011/12).

**Table2. Calculation of sub-indices and overall Ventura County Water Quality Index (2011/12).**

| <b>Site</b> | <b>Event</b> | <b>Salts</b> | <b>Bacteria</b> | <b>Nutrients</b> | <b>Organics</b> | <b>Metals</b> | <b>Toxicity</b> | <b>Overall Index</b> |
|-------------|--------------|--------------|-----------------|------------------|-----------------|---------------|-----------------|----------------------|
| ME-CC       | Dry          | 59           | 100             | 100              | 97              | 100           | n/a             | 91                   |
|             | Wet          | 100          | 29              | 100              | 92              | 79            | 100             | 83                   |
|             | Year         | 79           | 65              | 100              | 94              | 90            | 100             | 87                   |
| ME-SCR      | Dry          | 100          | 100             | 100              | 100             | 94            | n/a             | 99                   |
|             | Wet          | 100          | 30              | 100              | 100             | 58            | 100             | 81                   |
|             | Year         | 100          | 65              | 100              | 100             | 79            | 100             | 91                   |
| ME-VR       | Dry          | 100          | 100             | 100              | 100             | 100           | n/a             | 100                  |
|             | Wet          | 100          | 29              | 87               | 100             | 100           | 100             | 86                   |
|             | Year         | 100          | 65              | 94               | 100             | 100           | 100             | 93                   |
| All         | Dry          | 86           | 100             | 100              | 99              | 100           | n/a             | 97                   |
|             | Wet          | 100          | 30              | 96               | 97              | 79            | 100             | 84                   |
|             | Year         | 93           | 65              | 98               | 98              | 90            | 100             | 90                   |

## Rating System

Index results are reported as a number between 0 and 100, where 100 represents the best water quality, relative to objectives. The numbers are further ranked into five grades, each with a color code for graphing and mapping purposes (Table 3). The results for 2011/12 are shown in Table 4.

**Table 3. Ventura County Water Quality Index scores and grades.**

| Index score | Grade | Interpretation  |
|-------------|-------|---|
| 96 – 100    | A     | Excellent – Guidelines almost always met                      |
| 81 – 95     | B     | Very Good   |
| 66 – 80     | C     | Fair  |
| 46 – 65     | D     | Marginal  |
| 0 – 45      | F     | Poor – All constituents exceed guidelines with high frequency |

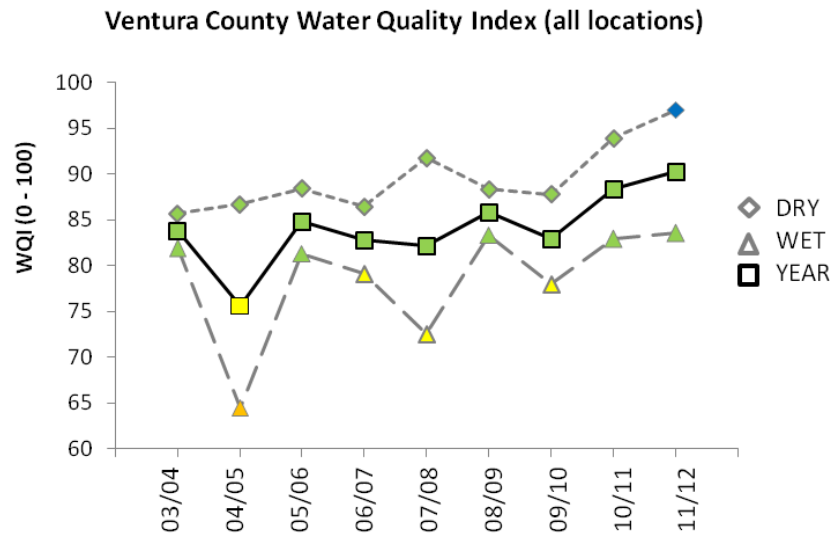
**Table 4. River water quality grades for Ventura County (2011/12).**

| Site   | Event | Salts | Bacteria | Nutrients | Organics | Metals | Toxicity | Overall Index |
|--------|-------|-------|----------|-----------|----------|--------|----------|---------------|
| ME-CC  | Dry   | D     | A        | A         | A        | A      | n/a      | B             |
|        | Wet   | A     | F        | A         | B        | C      | A        | B             |
|        | Year  | C     | D        | A         | B        | B      | A        | B             |
| ME-SCR | Dry   | A     | A        | A         | A        | A      | n/a      | A             |
|        | Wet   | A     | F        | A         | A        | D      | A        | B             |
|        | Year  | A     | D        | A         | A        | C      | A        | B             |
| ME-VR  | Dry   | A     | A        | A         | A        | A      | n/a      | A             |
|        | Wet   | A     | F        | B         | A        | A      | A        | B             |
|        | Year  | A     | D        | B         | A        | A      | A        | B             |
| All    | Dry   | B     | A        | A         | A        | A      | n/a      | A             |
|        | Wet   | A     | F        | A         | A        | C      | A        | B             |
|        | Year  | B     | D        | A         | A        | B      | A        | B             |

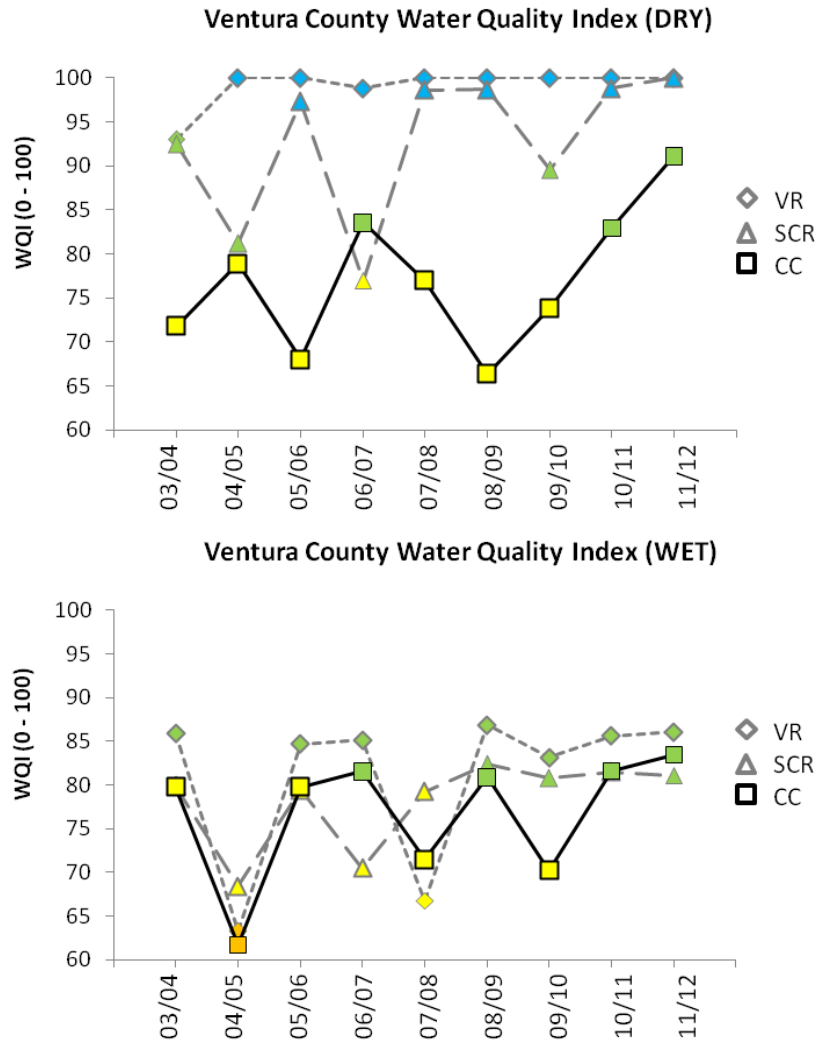
## What does the Index show?

Water quality has improved in Ventura County since 2003/04 (Fig. 1). The current water quality in the County of Ventura is generally good, with A and B grades at all locations. Index scores generally increase from ME-CC to ME-SCR to ME-VR, likely related to the degree of urbanization and agriculture in each watershed (Fig. 2). Water quality is usually better during dry weather events compared to storm events (Fig. 1, Fig. 2). Currently, salts are mostly responsible for

water quality impairments during dry weather, and bacteria and metals for impairments during wet weather.



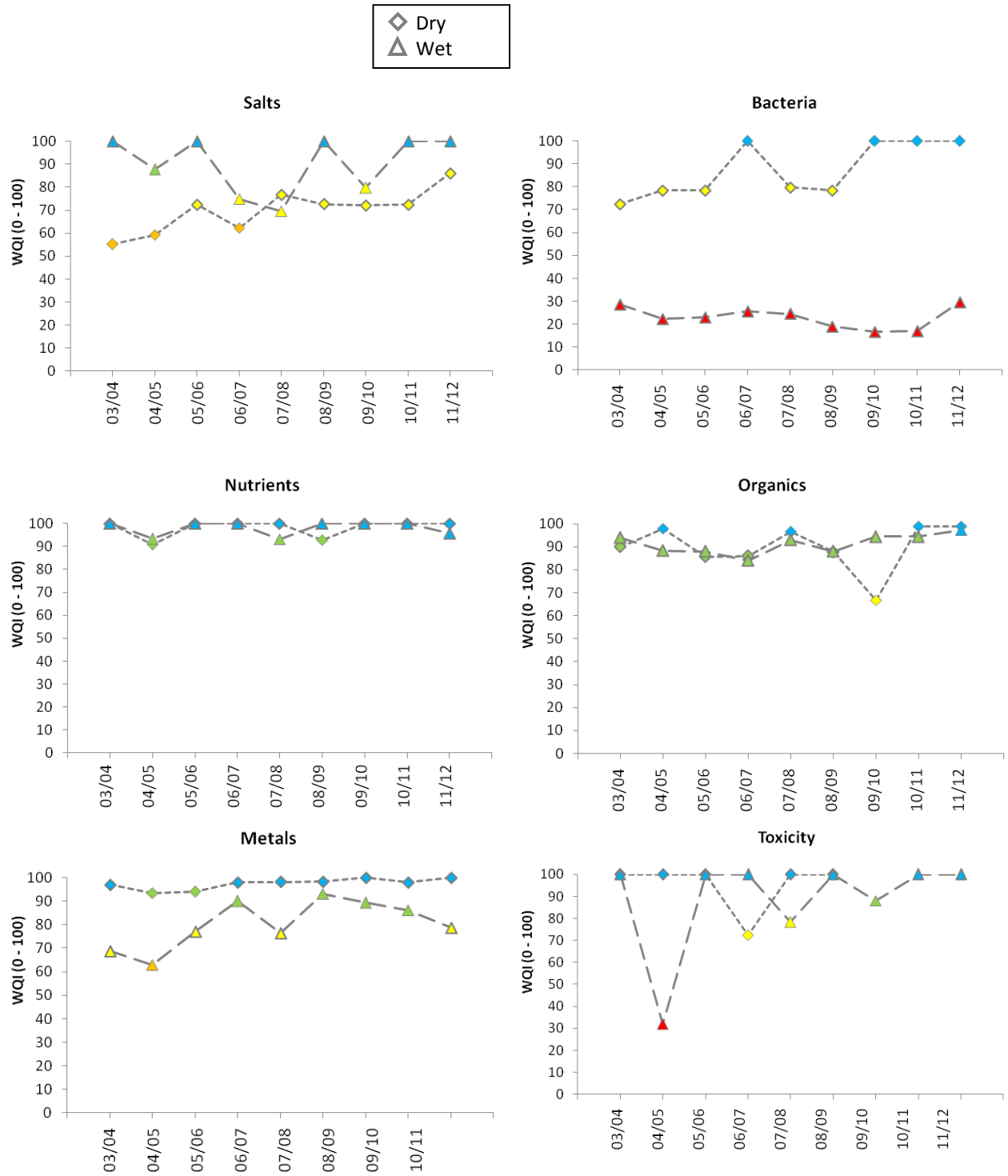
**Fig. 1. Water Quality Index trends for all locations combined.**



**Fig. 2. Water Quality Index trends for each receiving water station.**

Trends of sub-indices are shown in Fig. 3. The sub-indices quickly indicate what constituent classes are associated with drops of the overall Index. For instance, a low Index score in 2004/05 during wet weather (Fig. 1) was caused by low sub-index scores for metals and toxicity.





**Fig. 3. Sub-index trends with grades indicated by color codes**

## Appendix: Calculation of the Ventura County Water Quality Index

The formula used to calculate the Ventura County Water Quality Index is:

$$WQI = 100 - \left( \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

Where:

**F1** represents the number of water quality variables that do not meet objectives in at least one sample during the time period under consideration, relative to the total number of variables measured:

$$F_1 = \left( \frac{\text{Number of failed constituents}}{\text{Total number of constituents}} \right) \times 100$$

**F2** represents the number of individual measurements that do not meet objectives (exceedances), relative to the total number of measurements made in all samples for the time period of interest:

$$F_2 = \left( \frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100$$

**F3** represents the magnitude of exceedances relative to the objectives. This is an asymptotic capping function that scales the normalized sum of the exceedance magnitudes (nse) to yield a range between 0 and 100:

$$F_3 = \left( \frac{nse}{0.01 \times nse + 0.01} \right)$$

The *nse* variable represents the amount by which water quality is exceeding the relevant threshold. This is calculated by summing the magnitudes of exceedances of individual tests, and dividing by total number of tests:

$$nse = \frac{\sum_{i=1}^n \text{magnitude}_i}{\# \text{ of tests}}$$

For the case in which the test value must not exceed the objective:

$$magnitudo_i = \left( \frac{Concentration_i}{Objective_i} \right) - 1$$

For the case in which the test value must not fall below the objective (only for dissolved oxygen and toxicity):

$$magnitudo_i = \left( \frac{Objective_i}{Concentration_i} \right) - 1$$

*Parameter calculation notes:*

- *E. coli* concentrations are log-transformed before calculating F3. Log-transformation of *E. coli* concentrations is commonly applied in environmental statistics, to account for the log-normal concentrations distribution. Here, it ensures that *E. coli* exceedances do not low bias the index, relative to exceedances of other constituents.
- F3 is not included for constituents without water quality objectives. This ensures that no excessive weight is given to constituents for which (often multiple) environmentally relevant human health or ecotoxicity thresholds are available national or state recommended water quality criteria, but for which the State Water Resources Control Board has not formally adopted water quality objectives. Note that parameters F1 and F2 are still included, to ensure that exceedances of these important constituents are still reflected in the Ventura County Water Quality Index.