DPR Proposed Pathogen Control Criteria

§64669.45 and portions of §64669.80 & §64669.85

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Pathogen Control Criteria Overview

- Pathogen reduction targets to achieve specific health risk goals
  - Reference Pathogens
  - Tolerable Risk Goal
  - LRVs based on potential occurrence and safe drinking water level
- Treatment approval
  - Reliability - multi-barrier treatment, diverse treatment mechanisms, and extra log reduction capacity
  - Validate treatment LRVs to ensure effective pathogen removal
- System Control
  - On-line monitoring for critical control point critical limits
  - Control system that responds appropriately to LR deficiencies

Reference Pathogens

- Municipal wastewater is considered a surface water.

- Pathogens that are regulated in the Federal and California surface water treatment regulations:

  - *Giardia cysts*
  - *Cryptosporidium oocysts*
  - enteric virus

Risk goal

- Annual risk target of 10^{-4} infections per person per year based on guidance from the USEPA in developing the Surface Water Treatment Rule.

- State Water Board decided to specify a maximum daily risk of infection target:

  - 10^{-4} infections per person per year divided by 365 days to yield a daily risk target of 2.7×10^{-7} infections per person per day.

Derivation of Log Reduction Values (LRVs)

- Point estimate-based quantitative microbial risk assessment (QMRA)

	Enteric virus	*Giardia*	*Cryptosporidium*
Raw sewage maximum density	1E09 virus GC/L [(a)]	1E05 cysts/L [(b)]	1E04 oocysts/L [(c)]
Tolerable drinking water density	3.3E-07 virus/L [(d)]	6.8E-06 cysts/L [(e)]	1.4E-07 oocysts/L [(f)]
Ratio of drinking water to sewage density	3.3E-16	6.8E-11	1.4E-11
Required log reduction	16	10	11

(a) The maximum Norovirus concentration in gene copies per liter (GC/L) based on a literature review and meta-analysis presented by Eftim et al. (2017), Table 2.

(b) The high cyst concentrations found in untreated wastewater presented in Water Reuse, Metcalf and Eddy, 2007, Table 3-7.

(c) An oocyst concentration based on Norway (Robertson et al., 2006) and Melbourne (Tetra Tech, 2011) data, rounded up.

(d) Calculated using the dose-response model described by Teunis et al. (2008), page 1471.

(e) Calculated using the exponential dose-response model described Regli et al. (1991), Table 1.

(f) Calculated using the beta-Poisson dose-response model described by Messner et al. (2016), Table II.

Raw Sewage Maximum Pathogen Densities

- Based on the results of DPR-1 research project and literature review:

Enteric virus	Giardia	Cryptosporidium
1E09 virus GC/L	1E05 cysts/L	1E04 oocysts/L

Tolerable Drinking Water Pathogen Densities

- Calculated the tolerable drinking water densities for each pathogen using accepted dose-response relationships.
- Assumptions used in calculating the tolerable drinking water densities:
  - Annual consumption of 2 liters of water per day for 365 days
  - Dose-response model for enteric virus: Hypergeometric (Teunis et al., 2008)
  - Dose-response model for Giardia: Exponential (Teunis et al., 1997; Regli et al., 1991)
  - Dose-response model for Cryptosporidium: Beta-Poisson (Messner et al., 2016)
- Tolerable drinking water densities:

Enteric virus	Giardia	Cryptosporidium
3.3E-07 virus/L	6.8E-06 cysts/L	1.4E-07 oocysts/L

Ratios of Drinking Water to Sewage Densities

	Enteric virus	Giardia	Cryptosporidium
Raw sewage maximum density	1E09 virus GC/L	1E05 cysts/L	1E04 oocysts/L
Tolerable drinking water density	3.3E-07 virus/L	6.8E-06 cysts/L	1.4E-07 oocysts/L
Required log reduction to ensure microbiologically safe drinking water	16	10	11

DPR-1 Research Project: DPRisk Tool

DPRisk

version 1.0.1 (11.05.2020)

Sponsored by: The Water Research Foundation

THE Water Research FOUNDATION

- Model Specification
- Raw Wastewater Pathogen Concentrations
- Treatment Train
- Treatment Failure
- Management Barriers
- Exposure
- Dose-Response
- Results
- **PATTP Output**
- QMRA Output
- Summary of PATTP and QMRA Output
- Comparison of Risk Curves

Enteric virus

Summary statistics for Log Removal Values to achieve 10^{-4} annual risk:

	N	sd	mean	min	1st	5th	25th	median	75th	90th	95th	99th	max
1	10000	0	15.4862	15.4862	15.4862	15.4862	15.4862	15.4862	15.4862	15.4862	15.4862	15.4862	15.4862

Giardia

Summary statistics for Log Removal Values to achieve 10^{-4} annual risk:

	N	sd	mean	min	1st	5th	25th	median	75th	90th	95th	99th	max
1	10000	0	10.1609	10.1609	10.1609	10.1609	10.1609	10.1609	10.1609	10.1609	10.1609	10.1609	10.1609

Cryptosporidium

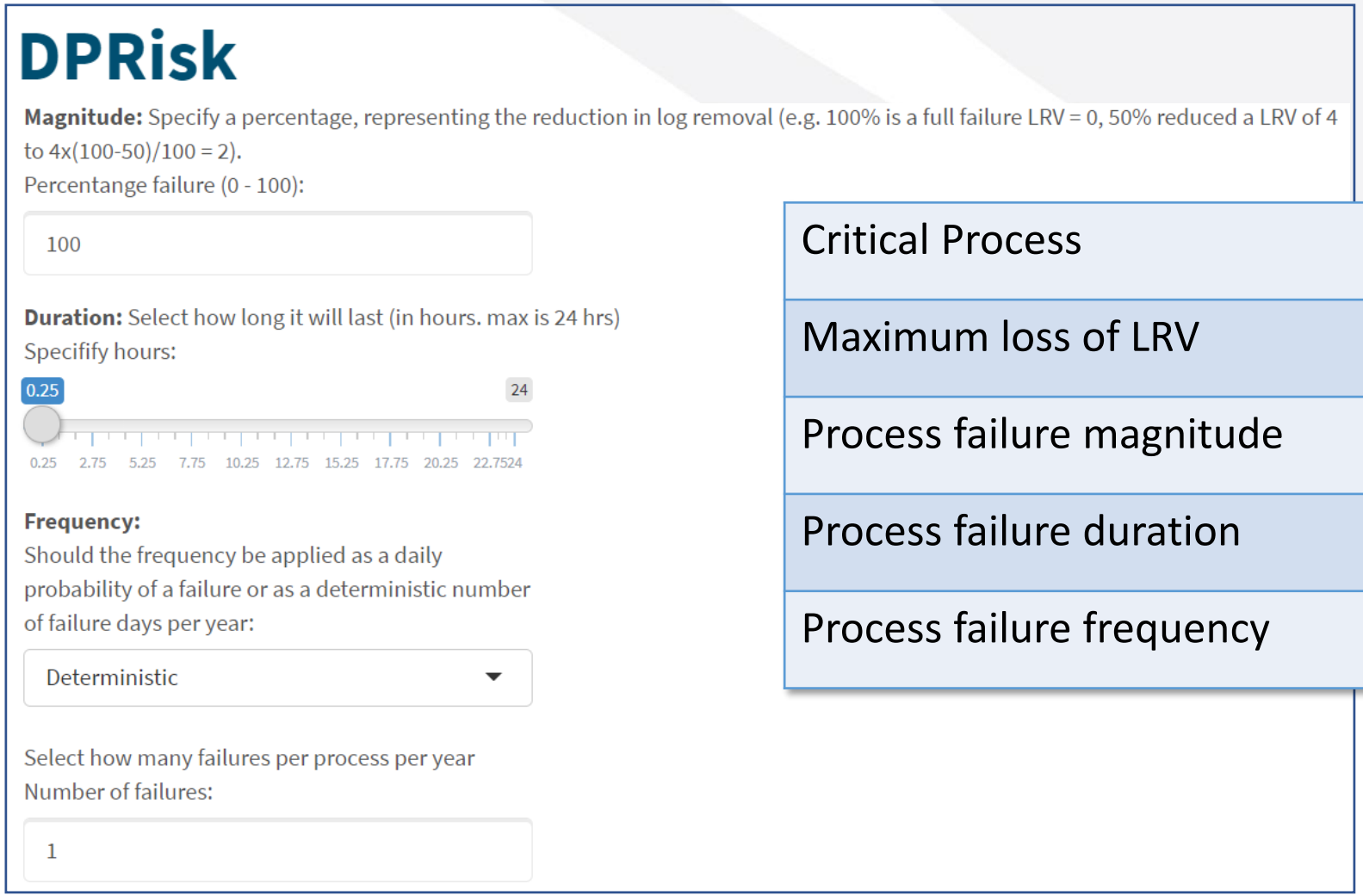
Summary statistics for Log Removal Values to achieve 10^{-4} annual risk:

	N	sd	mean	min	1st	5th	25th	median	75th	90th	95th	99th	max
1	10000	0	10.8448	10.8448	10.8448	10.8448	10.8448	10.8448	10.8448	10.8448	10.8448	10.8448	10.8448

Reliability

- The 2016 Expert Panel called for achieving reliability by "using a treatment train…with multiple, independent treatment barriers (i.e., redundancy) that meet performance criteria greater than the public health threshold log10 reduction value (LRV) goals established for microorganisms"
- To do so, State Water Board determined extra log reduction capacity beyond the required log reductions using a QMRA incorporating a conservative critical treatment failure scenario for each reference pathogen.
- State Water Board utilized the DPRisk tool for this purpose.

Failure Scenario



Critical Process	UV/AOP
Maximum loss of LRV	6 log
Process failure magnitude	100% (loss of all 6 logs)
Process failure duration	15 minutes
Process failure frequency	Once a year

Extra LRVs

- Additional LRVs required to be provided by the treatment train to ensure the calculated risk of infection associated with the failure scenario does not exceed a daily threshold of 2.7E-07:

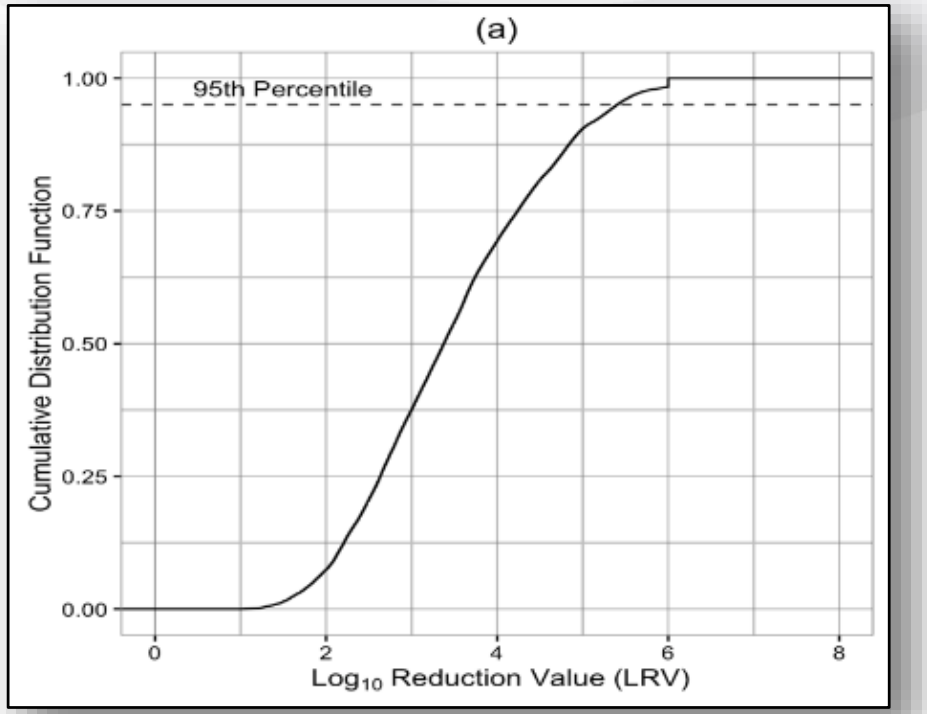
	Enteric virus	Giardia	Cryptosporidium
Excess log capacity to achieve a 2.7E-07 daily risk with failure scenario	4	4	4

Pathogen Reduction Treatment §64669.45(a)(1&2)

- For each reference pathogen the treatment train must:
  - Be validated to provide the LRV - 20 log for enteric virus, 14 log for Giardia cysts, and 15 log for Cryptosporidium oocysts
    → The redundant capacity
  - Include at least 4 pathogen barriers providing 1 to 6-log reduction
    → Ensures multi-barrier treatment
  - Include at least 3 treatment mechanisms (physical separation, chemical disinfection, and UV disinfection)
    → Ensures diverse processes

Pathogen Treatment Validation

- Validate treatment processes and trains
- Determine the LRV a treatment will achieve most of the time (5th percentile LRV)
- Correlate performance with a measurable parameter and identify limits indicating failure



Validation Procedure
§64669.45(a)(3-4)

- Identify the mechanism(s) of pathogen reduction by process
- Identify the pathogens addressed or appropriate surrogates for pathogens for validation study
- Identify influencing factors that affect efficacy of process
- Describe method to collect and analyze the data
- The lower 5th percentile LRV demonstrated is the LRV credited for process
- Determine the critical limit(s)

Validation Procedure
§64669.45(a)(5&6)

- The treatment train LRV for enteric virus, Giardia, and Cryptosporidium is the sum of the treatment process validated 5th percentile LRVs for each pathogen.

- The treatment train must include UV disinfection with a dose of at least 300 mJ per cm^2.

Validation Opportunities

- The treatment required for CEC removal (O3/BAC – RO – AOP) can be validated for pathogen reduction and used to meet the bulk of the required LRVs

- Features of a raw water augmentation project, such as transport time and the “drinking water treatment plant” can be validated for pathogen LRVs

Treatment Operation and Monitoring §64669.45(b)

- The treatment train must be operated continuously to achieve LRVs of 20, 14, and 15 for virus, Giardia, and Cryptosporidium respectively.

- The treatment LRVs provided must be tracked continuously with a SCADA system using on-line monitoring as determined in the validation.

Pathogen Treatment Operation Limits
§ 64669.45 (b) (2-5)

- Discontinue delivery of water to the distribution system if the treatment train is not achieving LRVs of 16/10/11 for virus, Giardia, and Cryptosporidium respectively

- Discontinue delivery if the minimum # of treatment processes or treatment mechanisms are not provided.

- Discontinue delivery within 24 hours if the treatment train is not achieving minimum design LRVs of 20/14/15.

Pathogen Treatment Monitoring & Control §64669.45(b)(1 & 6-8)

- Treatment LRVs must be tracked continuously with a SCADA system utilizing on-line monitoring for each process that was validated
- Control system must have associated alarms that indicate when the process is not operating as designed
- Control system must be designed to identify a failure of a process to meet its critical limit
- Control system must be designed to automatically stop the flow of inadequately treated water to the drinking water system before unsafe water reaches the system
- Notify the SWB when delivery of water must be halted

Operations Plan
§64669.80

- Describe how the SCADA system identifies LR treatment performance status and failures

- Describe how the SCADA system identifies a failure to meet the required log reduction and be able to automatically prevent water from reaching the distribution system

Pathogen…Control Point Monitoring and Response Plan - §64669.85

- For failure to provide 16/10/11 log reduction of virus, Giardia, and Cryptosporidium - SCADA must identify the failure conditions, alert the operator, halt the distribution of water, and generate a record of the incident
- A pathogen control point parameter not meeting the critical limit means that process is not allowed the validated LRV
- Response times (j & k) – total time required from a CCP failure to the termination of flow to the distribution system must be provided by the subsequent flow path

Questions?