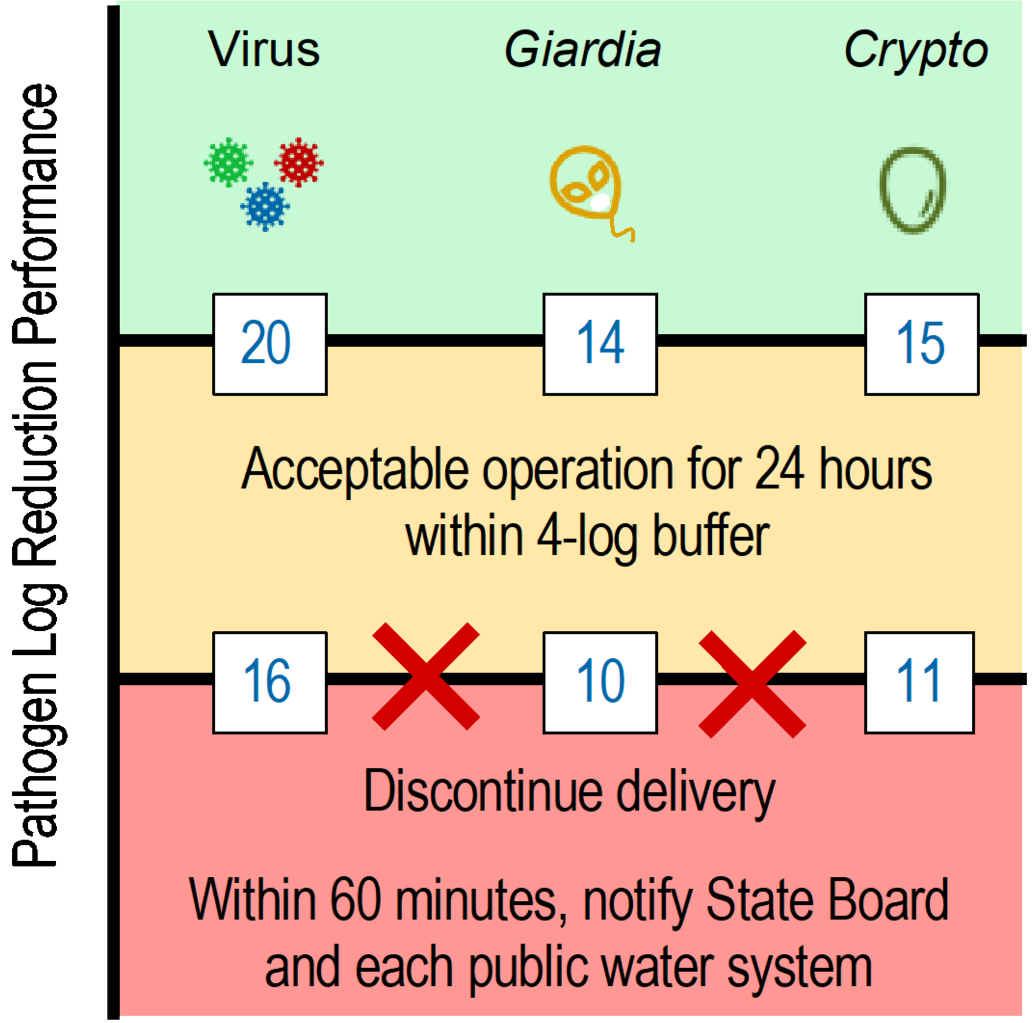
NWRI DPR Expert Panel – Pathogen Control Briefing #2

January 26, 2022

Review of Draft Criteria - Approach

- What is in the criteria?
- What is the basis for the pathogen log reduction requirements?
- How does one judge compliance with the LRT criteria?
  - Do we need to be compliant 100% of the time? 95% of the time?

What are the criteria?



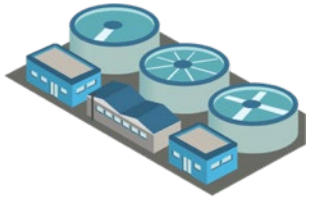
Derivation of LRVs

Calculating Risk

1. Exposure Assessment

2. Dose-Response

Raw wastewater

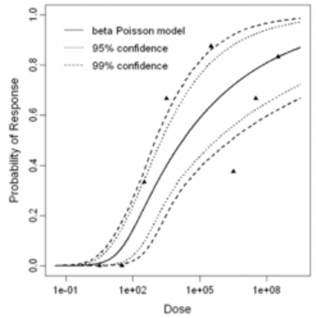


Treatment

Drinking water levels

Drinking water consumption

Exposure



Dose-response

Risk

There are a lot of decisions to consider when calculating risk…

What data should we use?

What about molecular data?

Should we use a point estimate or distribution?

Is treatment constant or does it vary?

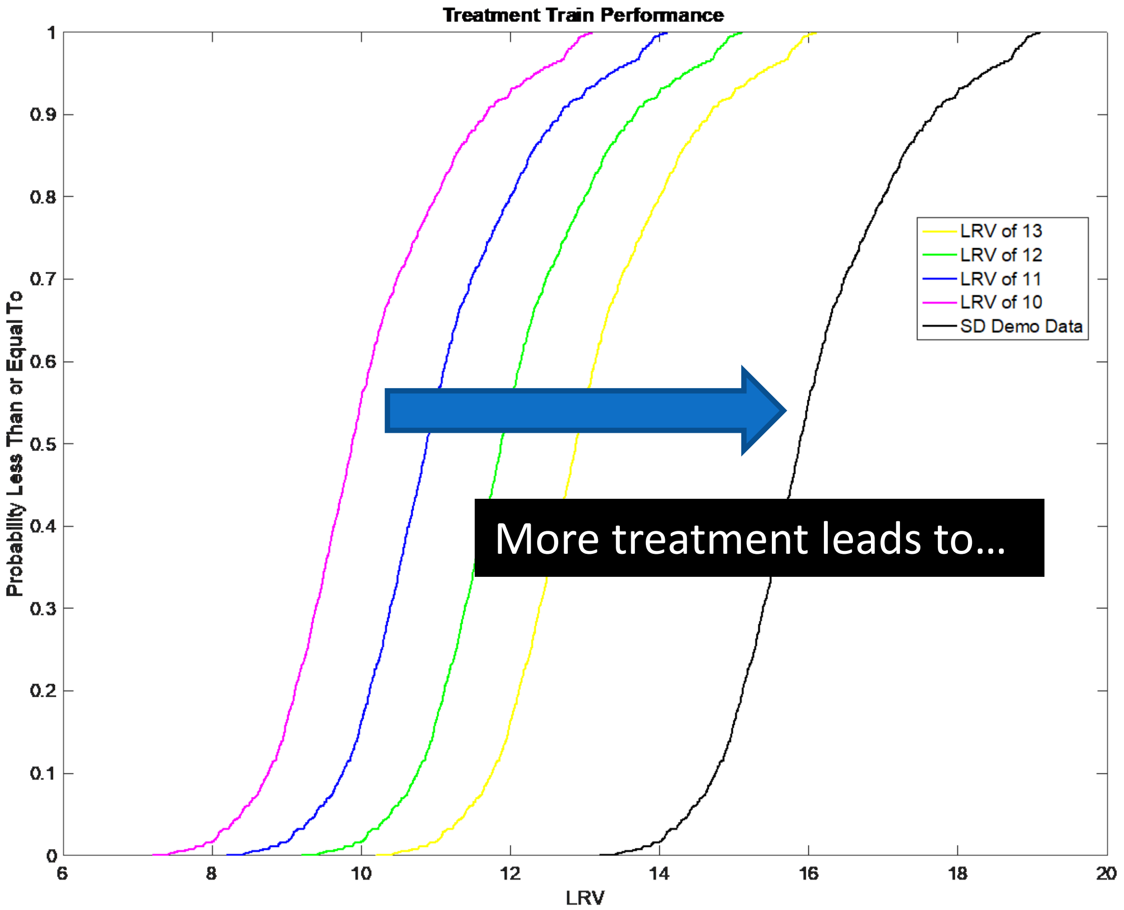
How do you account for failures?

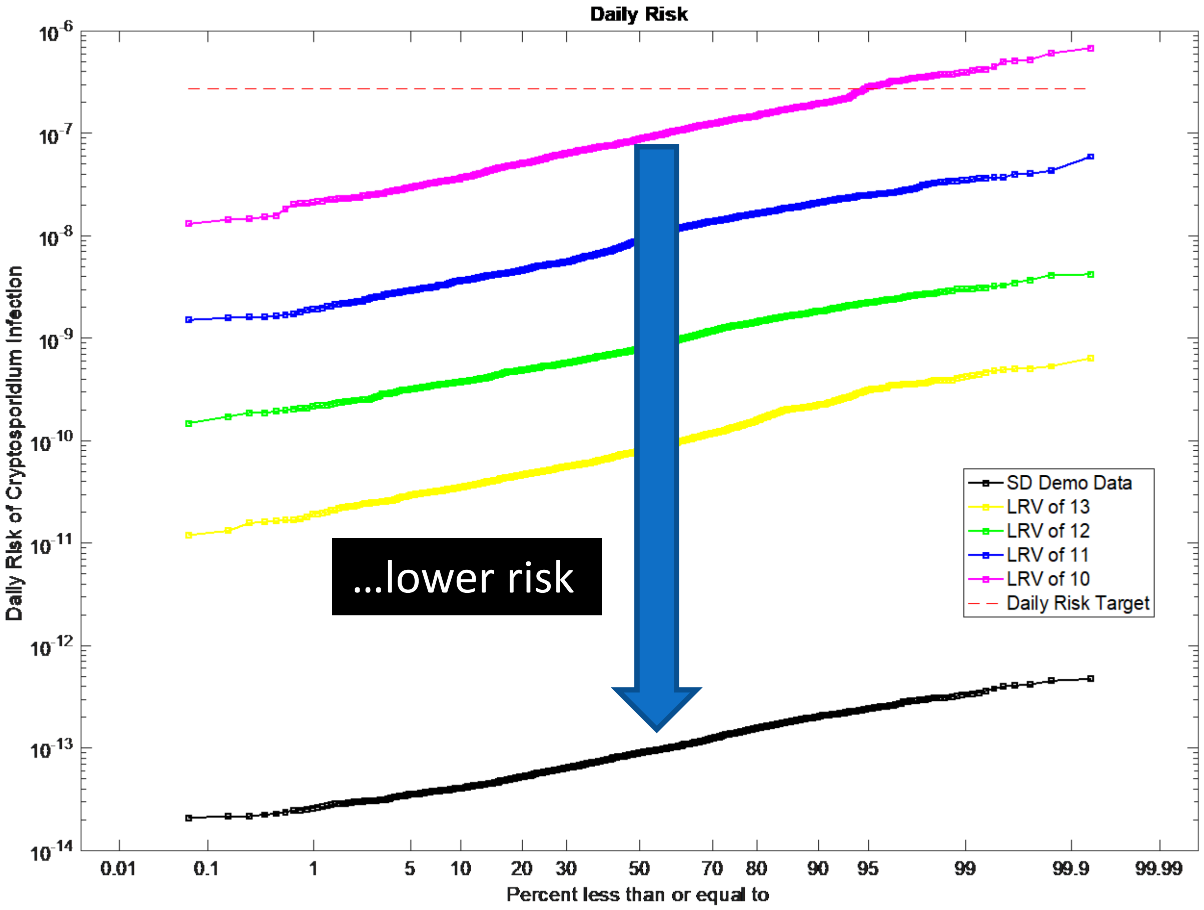
How much water do people drink?

Which D-R functions to use?

Redundancy and Risk

"To minimize the chance that the required log reductions necessary to meet the health objective are not consistently met, DPR projects must provide log reduction capacity in excess of the basic LRVs (redundant LRV treatment)."



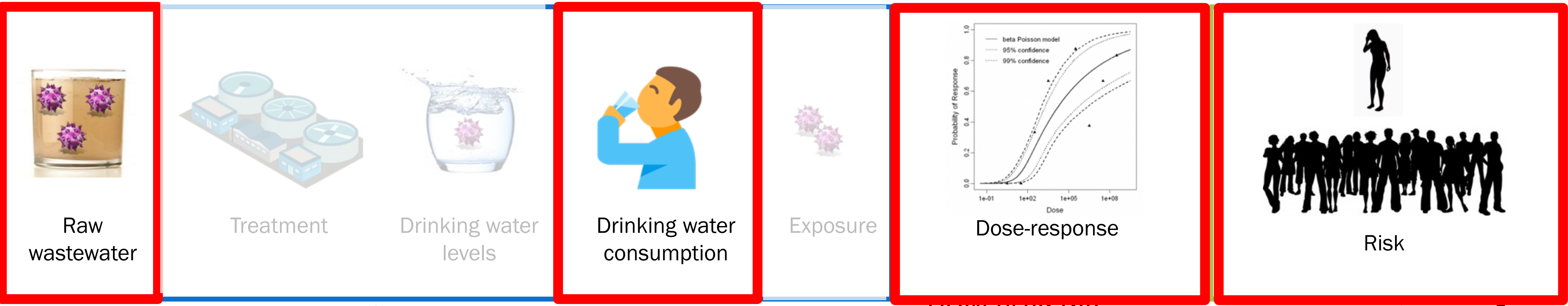


Draft Criteria LRVs

Calculating the Benchmark Treatment – Virus

1. Exposure Assessment

2. Dose-Response



DDW used point estimate of highest concentration of norovirus recorded (1E9 GC/L)

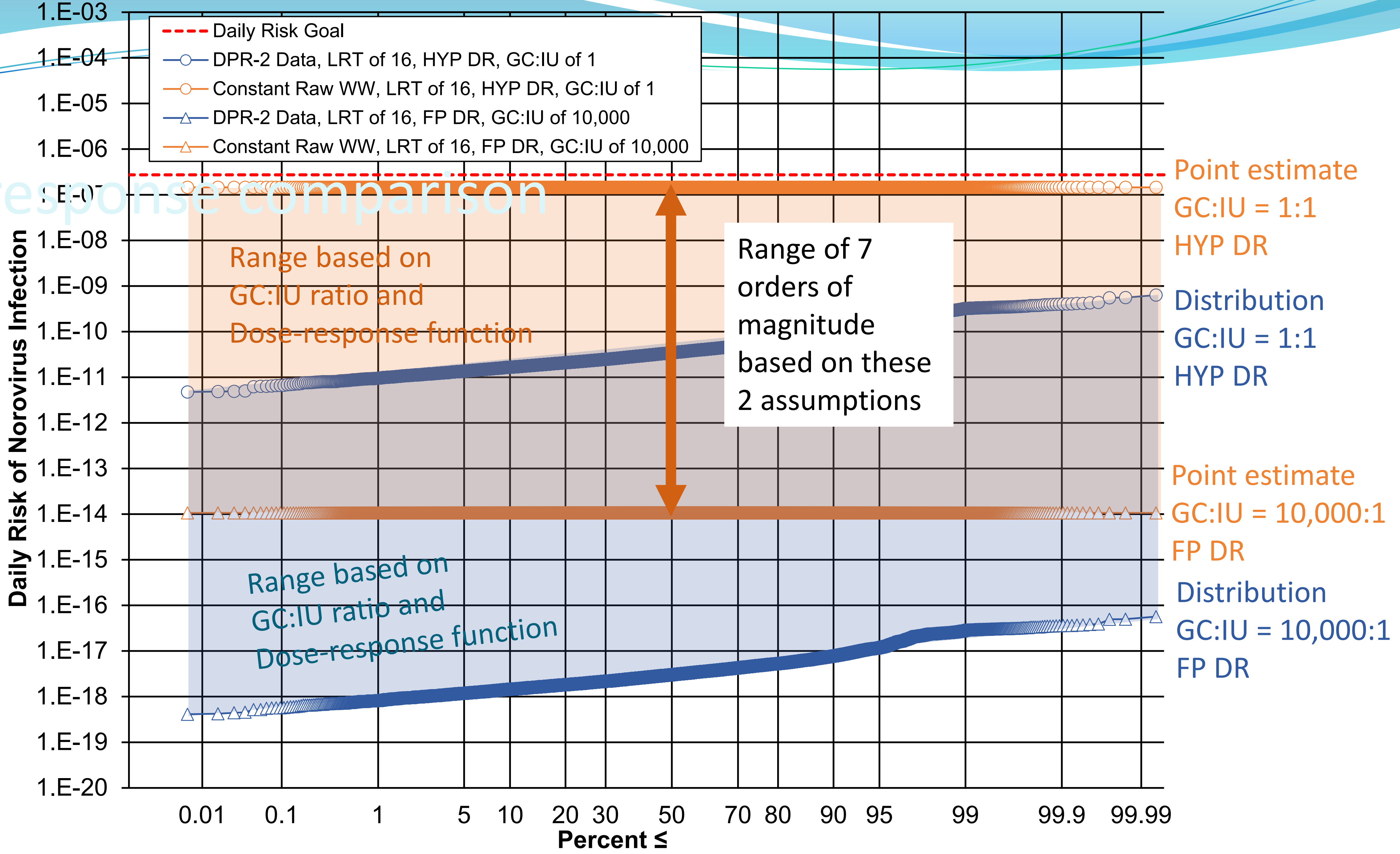
DDW assumed consumption of 2 L/day

DDW used the hypergeometric dose-response (Teunis et al. 2008; alpha = 0.04; beta = 0.055)

Daily risk of $2.7x10^{-7}$

Dose-response comparison

LRT of 16
HYP DR vs FP DR
GC:IU of 10,000:1



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Previous Recommendations from 1/13/22 Mtg

Recommendation:

- **Pathogen concentrations**: use DPR-2 distributions

Continue to Evaluate:

- **Type of data**: molecular and culture data
- **GC:IU ratios**: point estimates and ranges
- **Dose-response**: consider multiple functions

Norovirus – Range of Assumptions

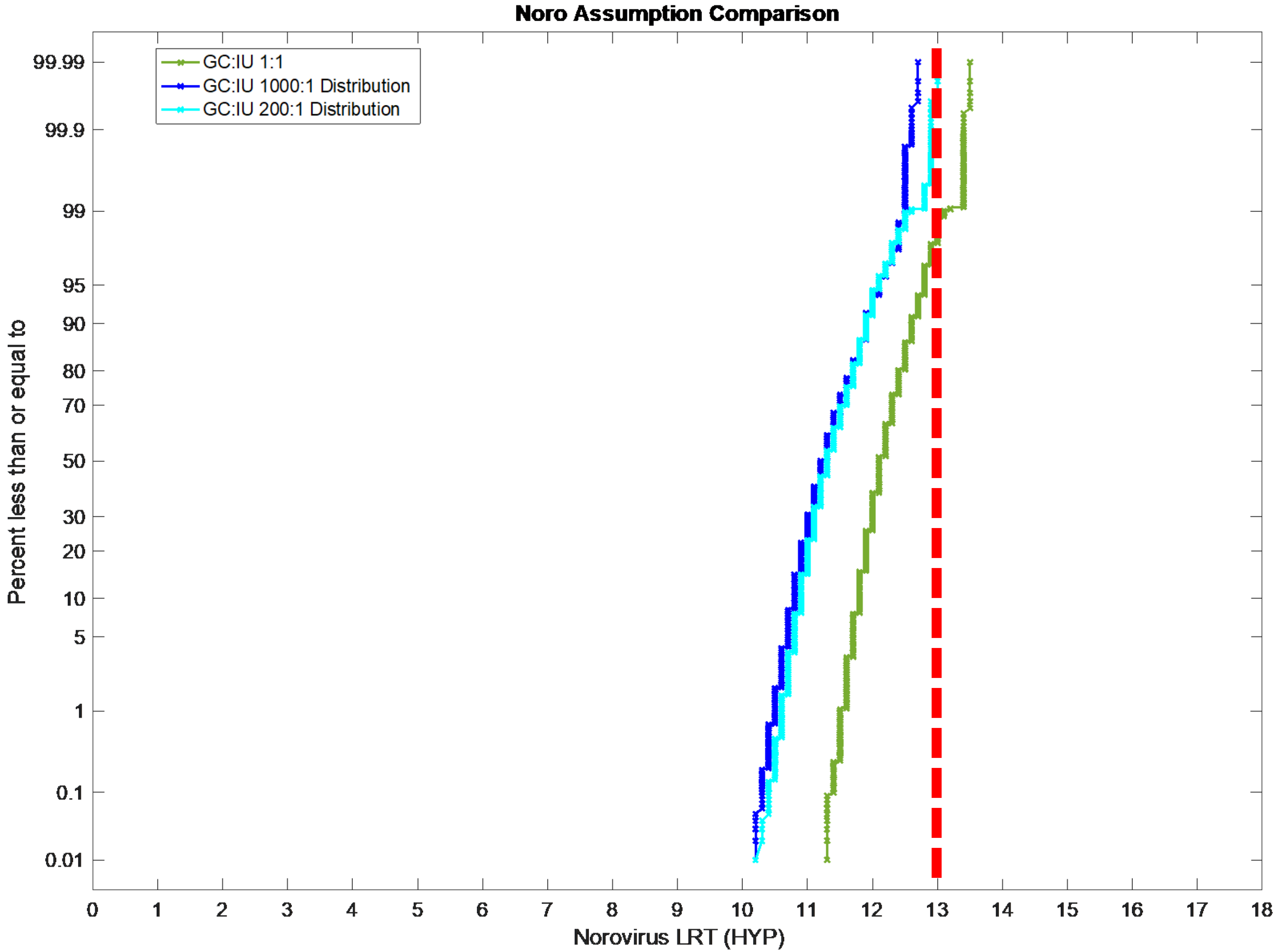
- Raw WW:
  - DPR-2 Distribution: μ_{log} = 4.0; σ_{log} = 1.2
- GC:IU
  - Option 1 = GC:IU of 1:1[1]
  - Option 2 = Uniform distribution of GC:IU of 200:1 to 1:1[2]
  - Option 3 = Uniform distribution of GC:IU of 1,000:1 to 1:1[3]
- Dose-Response
  - Hypergeometric (conservative)
  - Fractional-Poisson

[1] Ratio of GC:IU will not be constant (Gerba and Betancourt (2019) Assessing occurrence of waterborne viruses in reuse systems)

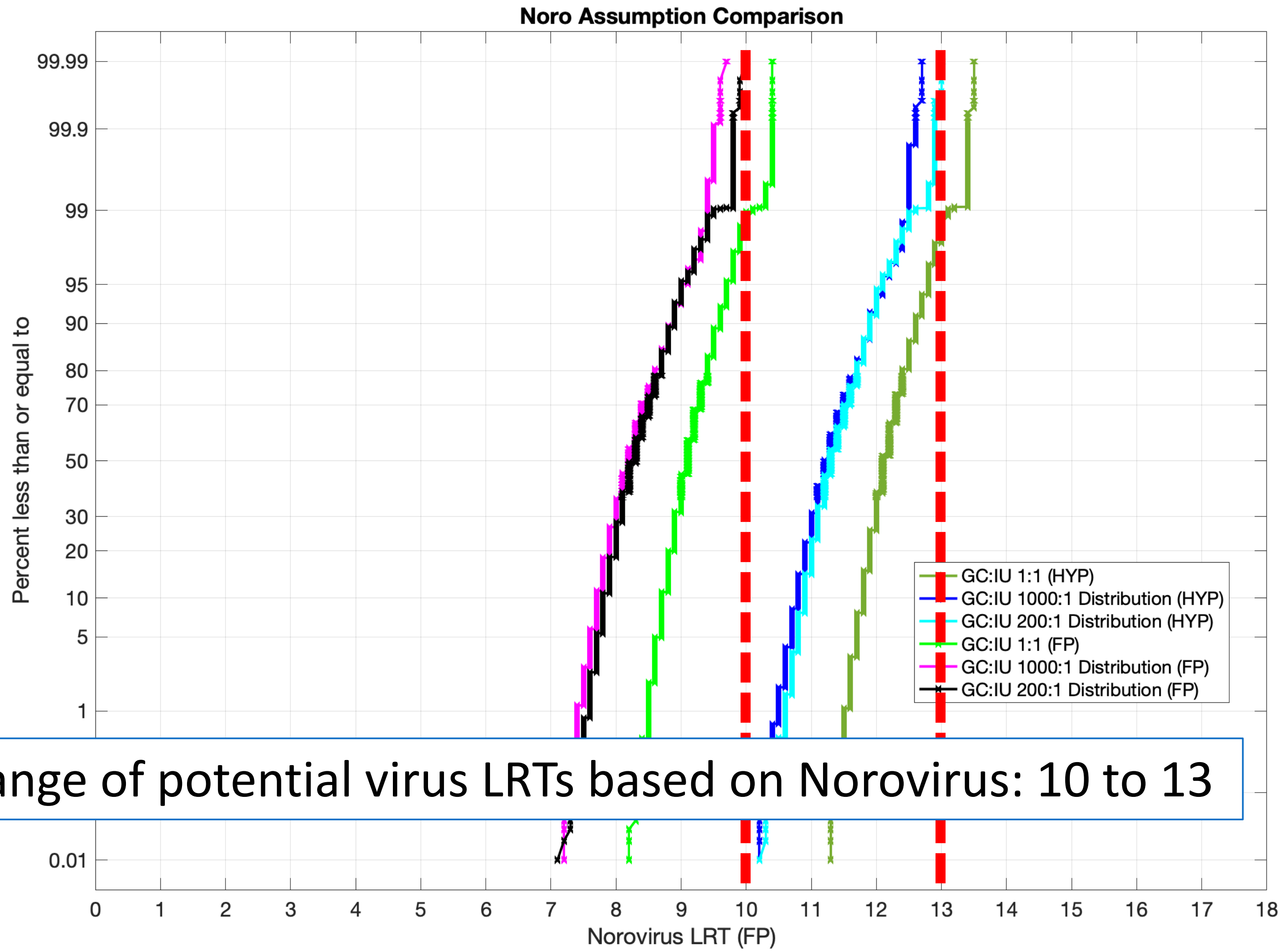
[2] Minimum ratio of 200:1 (Donia et al. (2010) Statistical correlation between enterovirus GC numbers and infectious viral particles in wastewater samples)

[3] Ratios of 1:1 to 10,000:1 (and up to 100,000:1) reported in DPR-2

Norovirus Required LRTs (Hypergeometric D-R)



Norovirus Required LRTs (impact of HYP and FP)



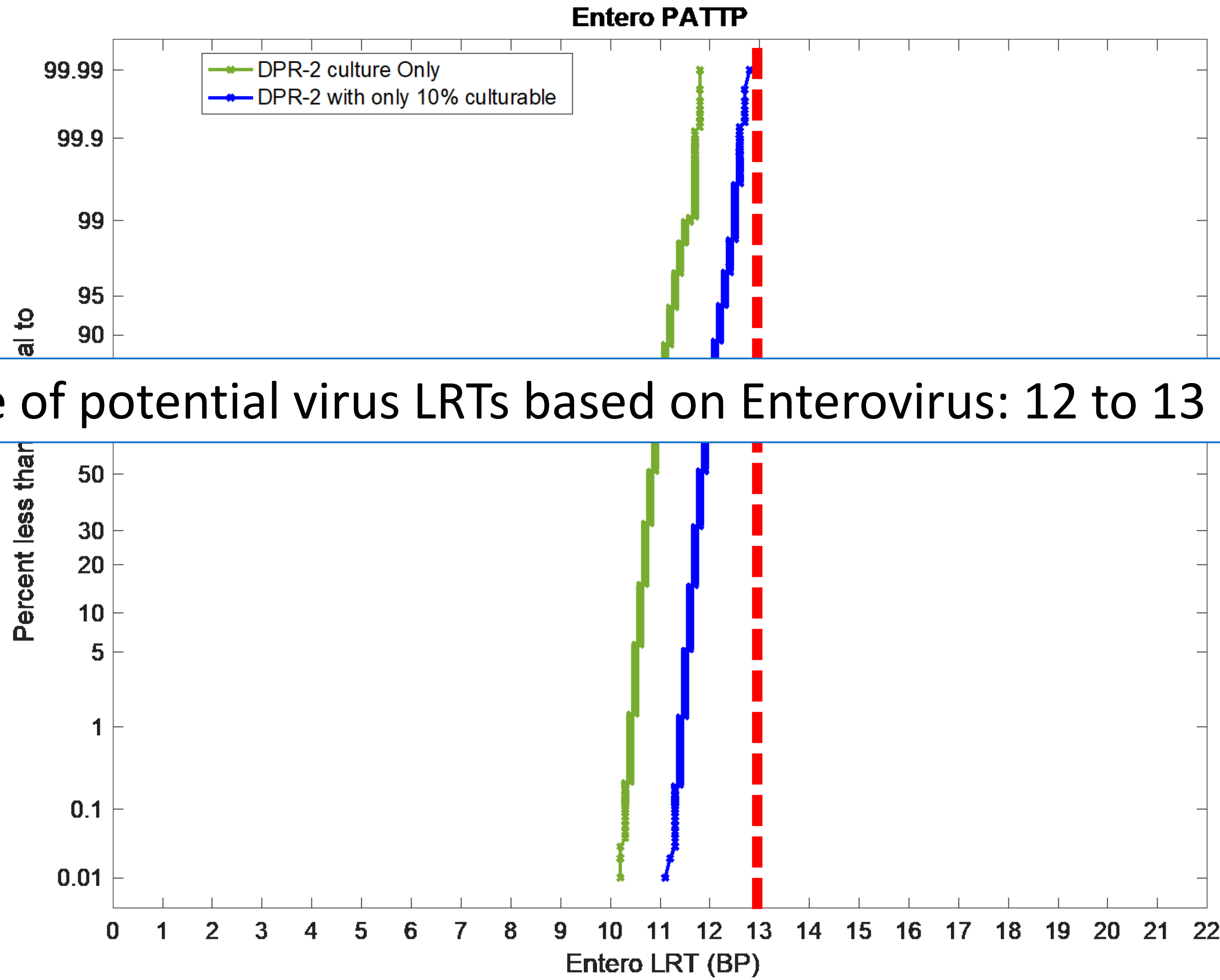
Range of potential virus LRTs based on Norovirus: 10 to 13

Enterovirus Assumptions

- Raw WW:
  - DPR-2 Distribution[1]: $\mu_{log} = 3.2$; $\sigma_{log} = 1.0$
  - Assume 10% of total viruses were culturable[2]: $\mu_{log} = \underline{4.2}$; $\sigma_{log} = 1.0$
- D-R
  - **Use Rotavirus D-R (Beta Poisson) as conservative estimate – in line with virus requirements for Surface Water Treatment Rule and California IPR regulations**

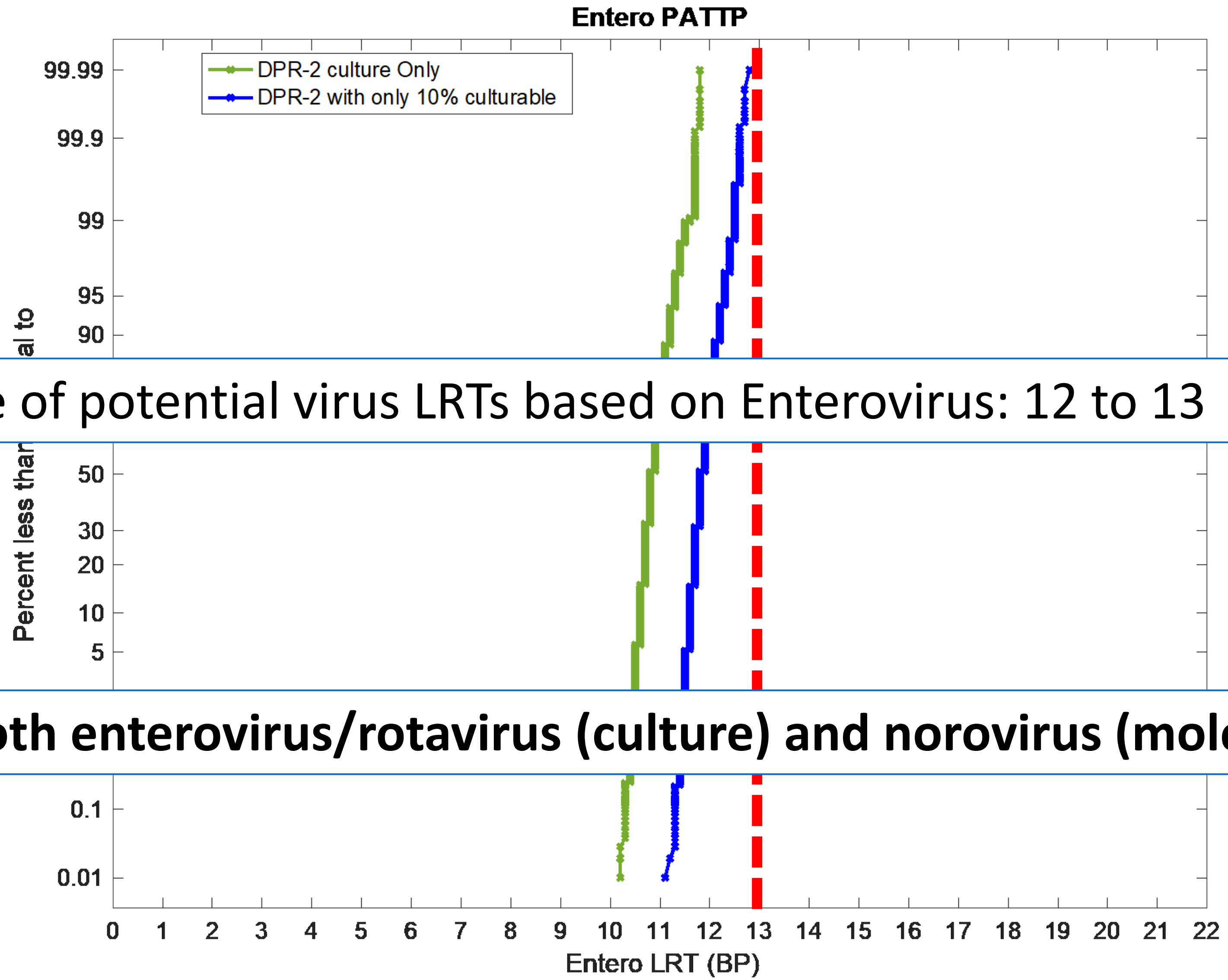
[1] Second passages were completed for all flasks for both the BGM and A549 cell culture assay,
[2] Safety factor of 10 is reasonable estimate (Gerba and Betancourt 2019).

Enterovirus Required LRTs



Range of potential virus LRTs based on Enterovirus: 12 to 13

Enterovirus Required LRTs

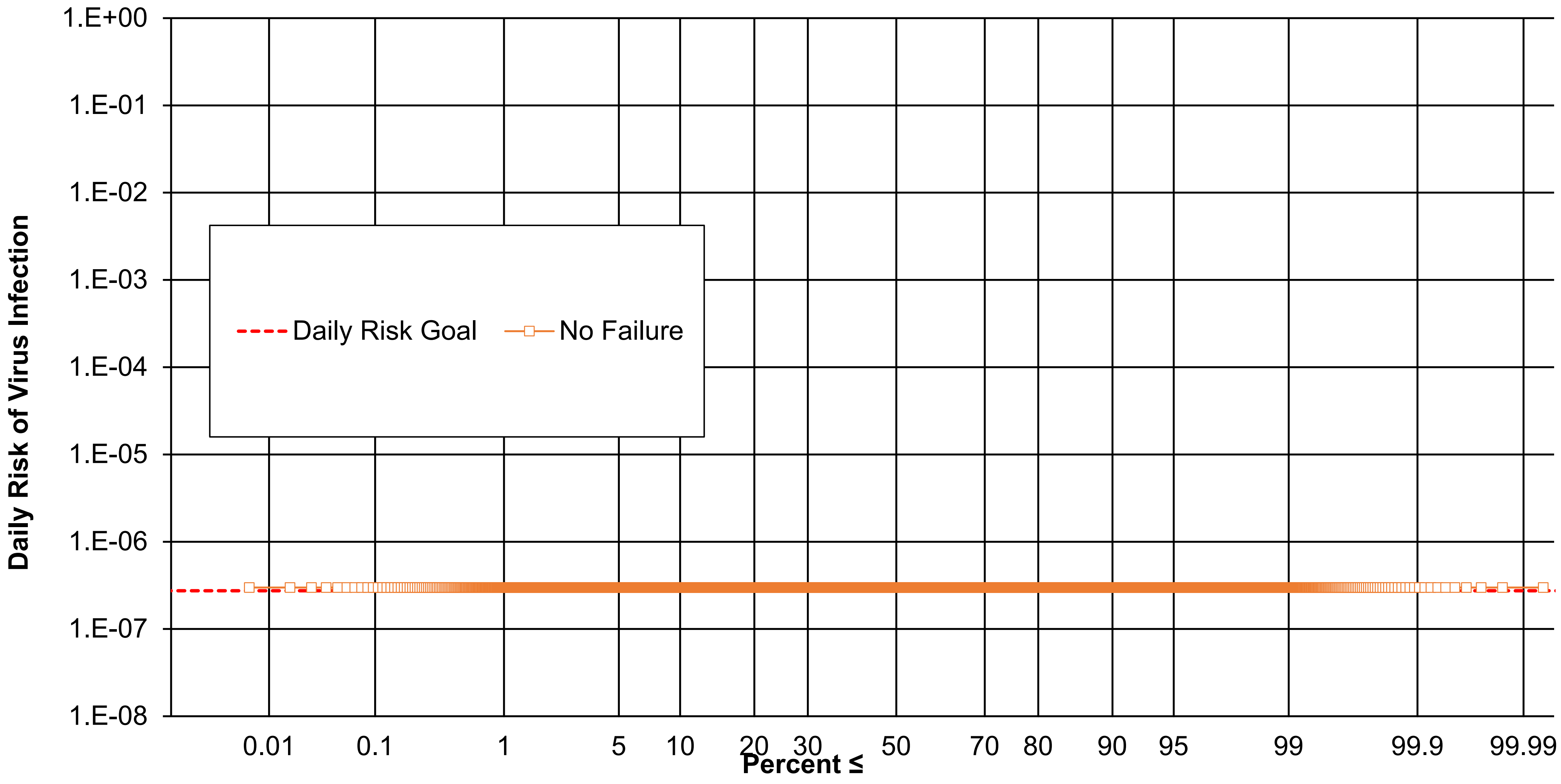


Range of potential virus LRTs based on Enterovirus: 12 to 13

Upper-end of both enterovirus/rotavirus (culture) and norovirus (molecular) is 13 LRV

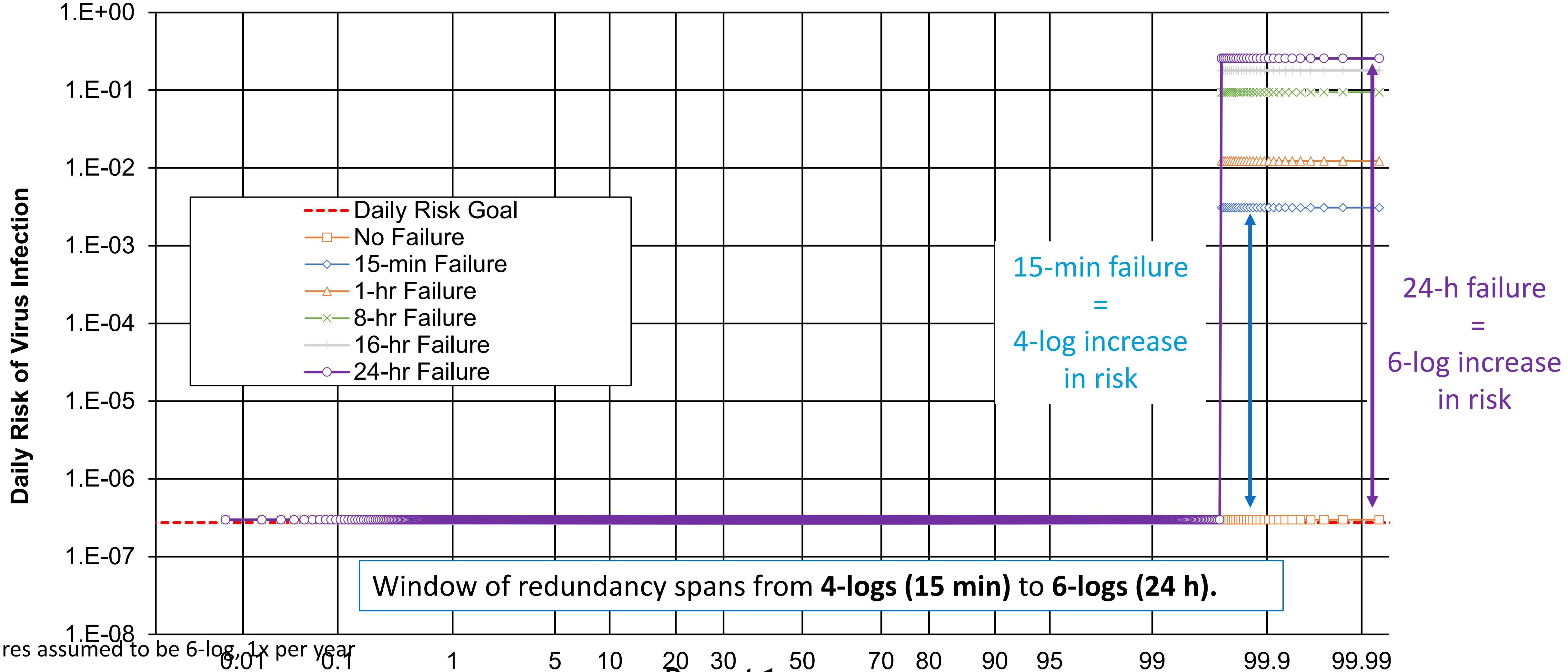
Failures

Failure increases risk from 4- to 6-logs



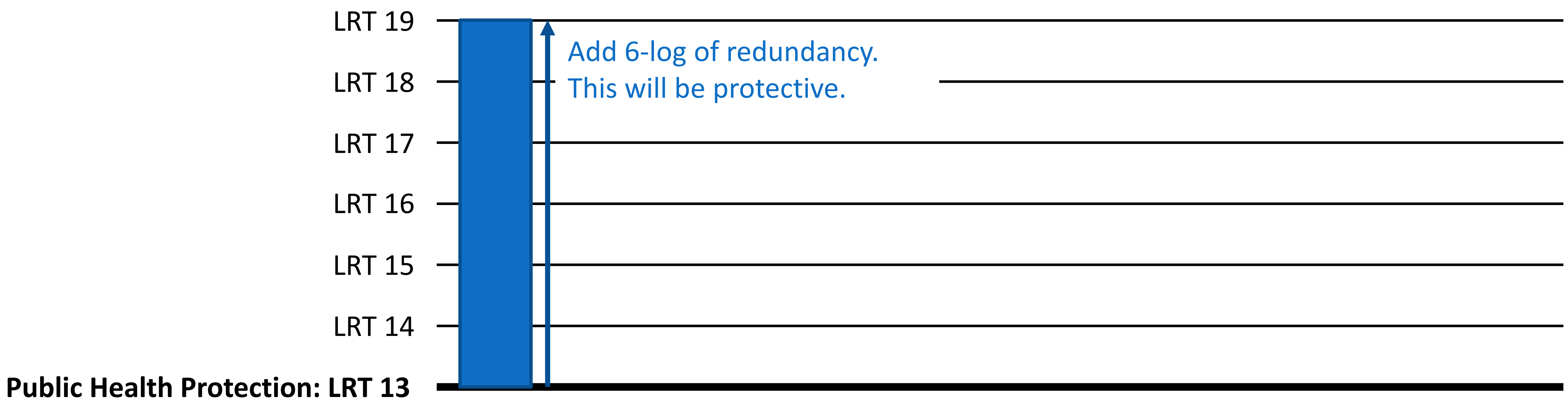
Failures assumed to be 6-log, 1x per year

Failure increases risk from 4- to 6-logs

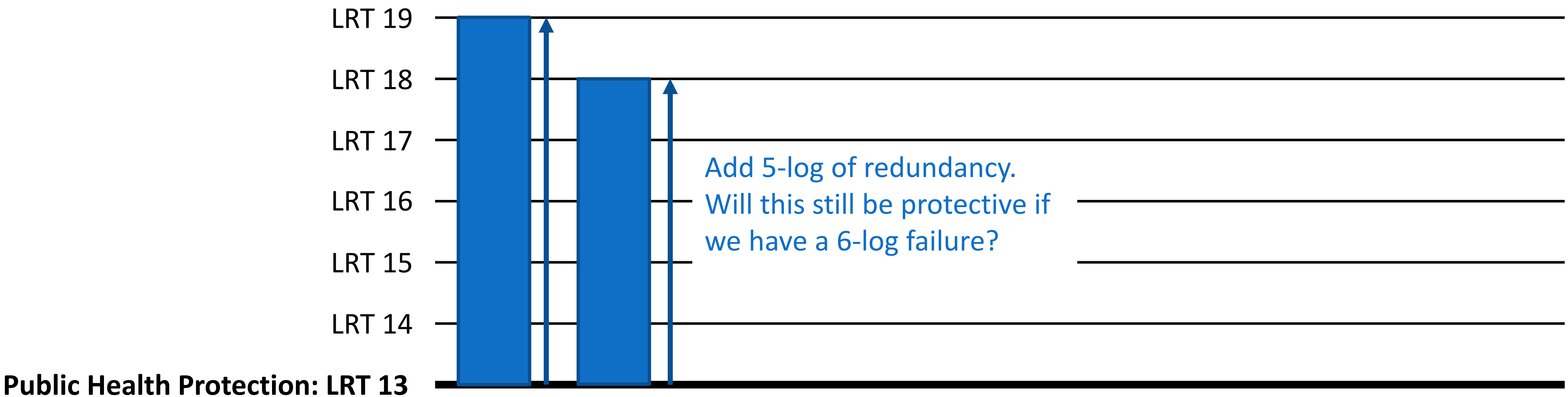


Failures assumed to be 6-log, 1x per year

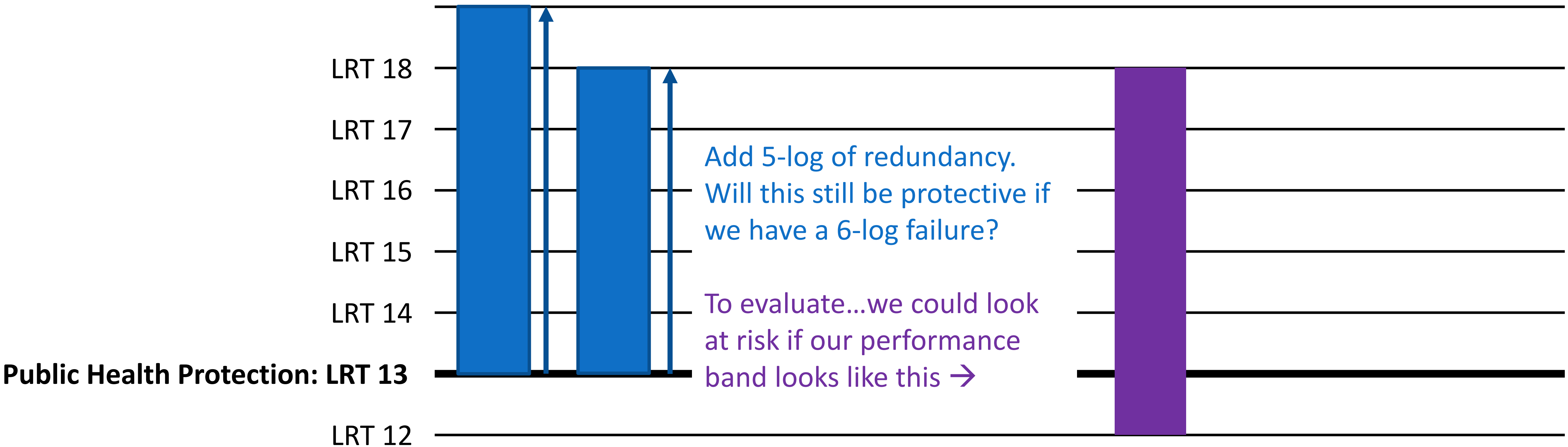
Approach for Evaluating Redundancy



Approach for Evaluating Redundancy



Approach for Evaluating Redundancy

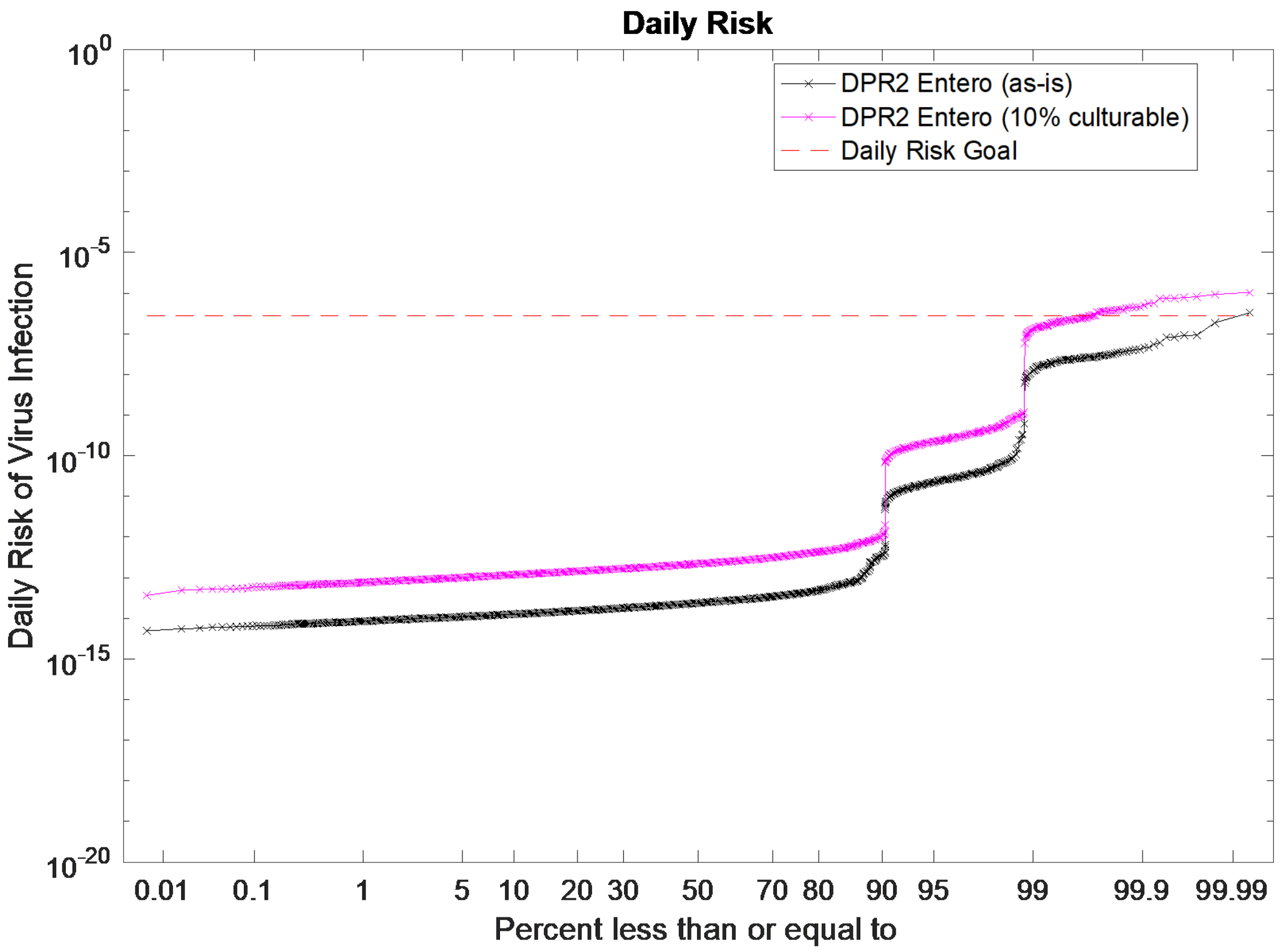


Evaluating Risk – Performance Assumption

- Treatment goals: 13 LRT + 5 LRT redundancy = 18
- Model includes intermediate and complete failure (undetected) scenarios
  - 18 LRT – 90% -- performance typically at design conditions (13 + 5)
  - 15 LRT – 9% -- periods with lower redundancy (13 + 2)
  - 12 LRT – **1%** -- full 6-log failure occurring 1% of the time (18 – 6)
- DDW assumed one 15-min, 6-log failure occurring 1x/year
  - **1%** is more conservative than DDW assumption (0.003%)

Virus Comparison – Daily Risk

12 LRT – 1%
15 LRT – 9%
18 LRT – 90%

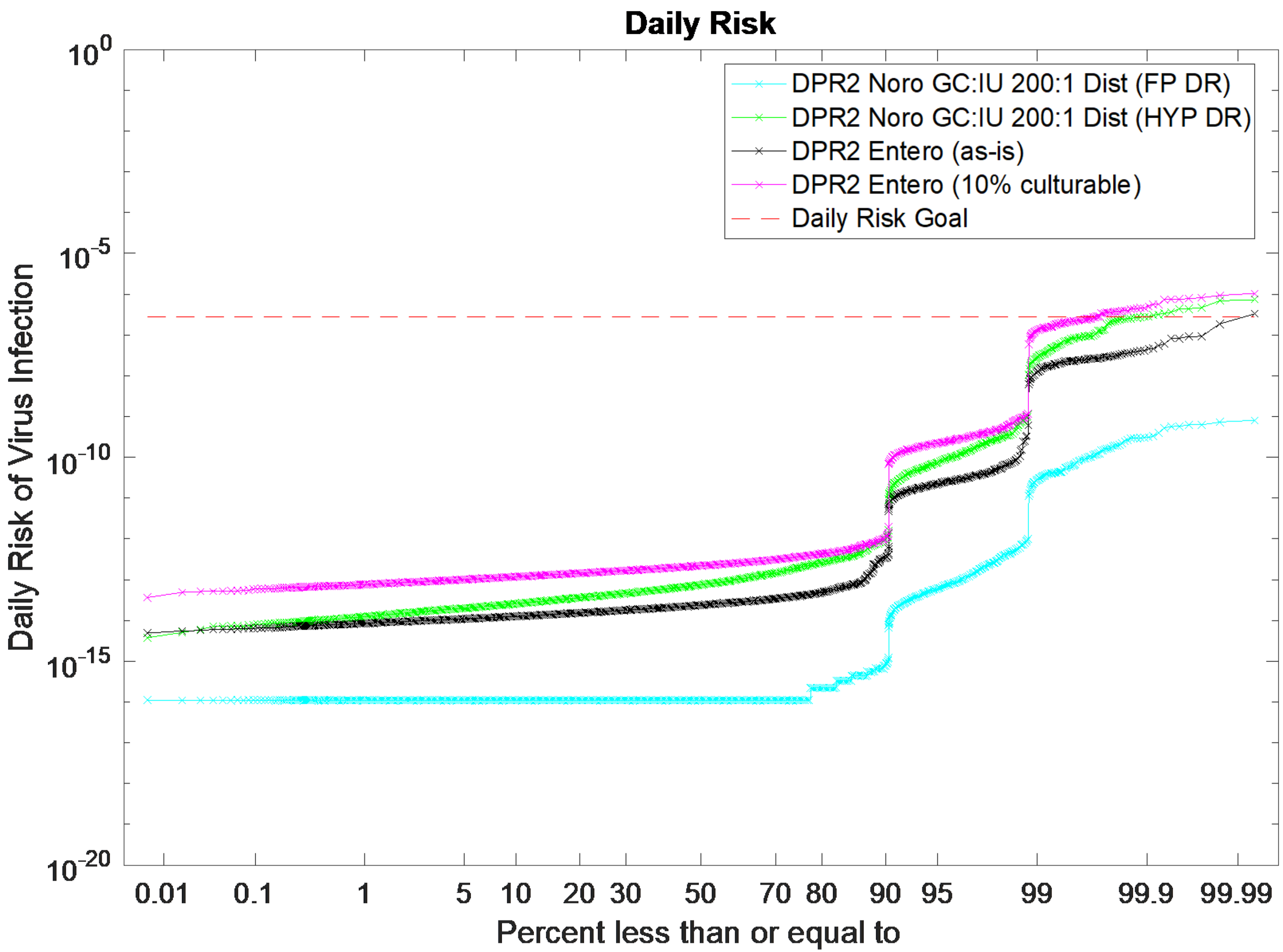


Entero – 10% culturable

Entero – no adjustment

Virus Comparison – Daily Risk

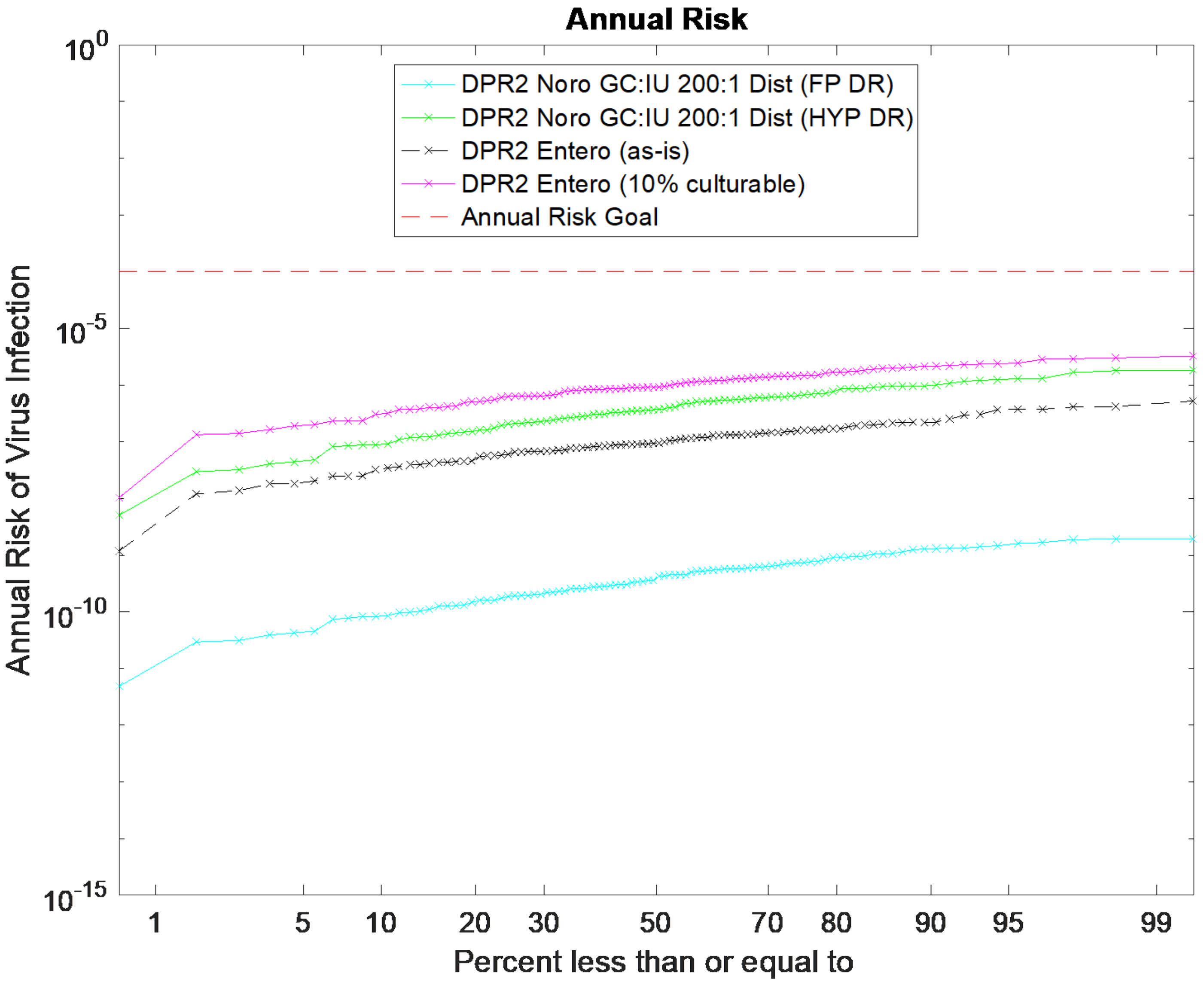
12 LRT – 1%
15 LRT – 9%
18 LRT – 90%



Entero – 10% culturable
NoV – hypergeometric
Entero – no adjustment
NoV – fractional Poisson

Virus Comparison – Annual Risk

12 LRT – 1%
15 LRT – 9%
18 LRT – 90%

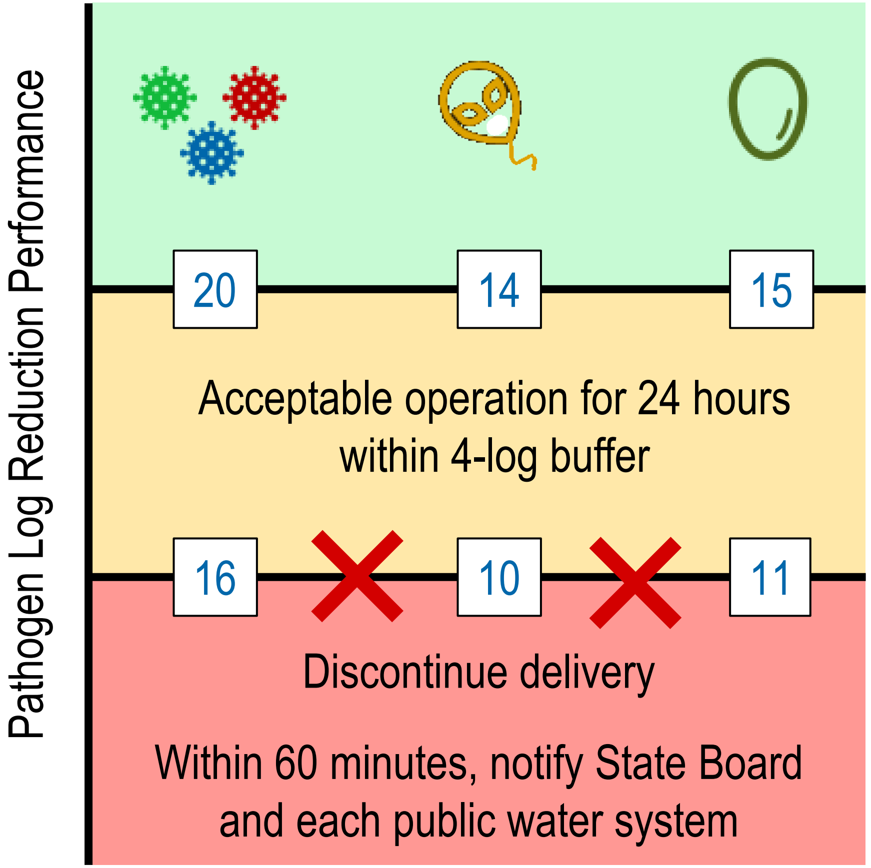


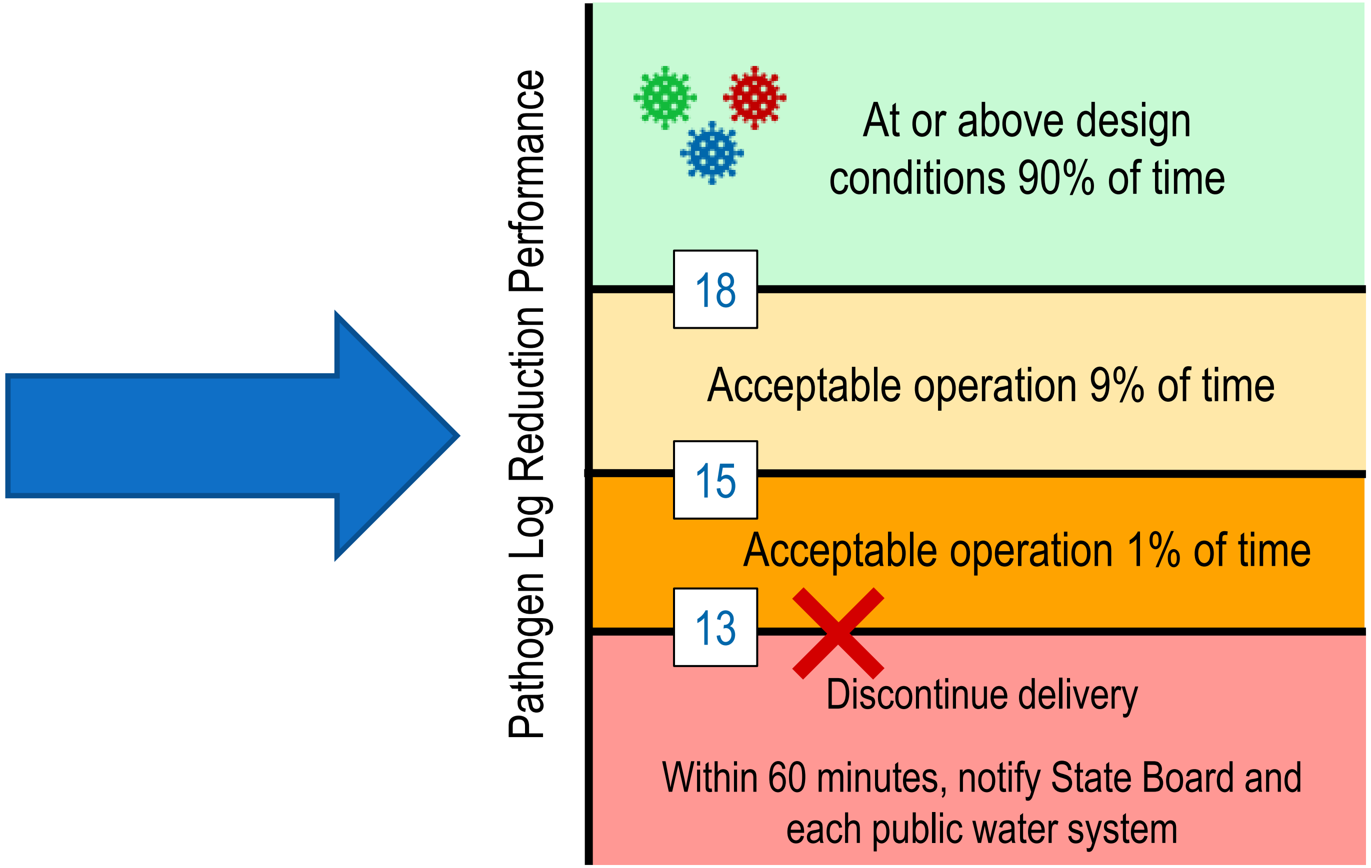
Entero – 10% culturable
NoV – hypergeometric
Entero – no adjustment
NoV – fractional Poisson

Potential Virus Requirements

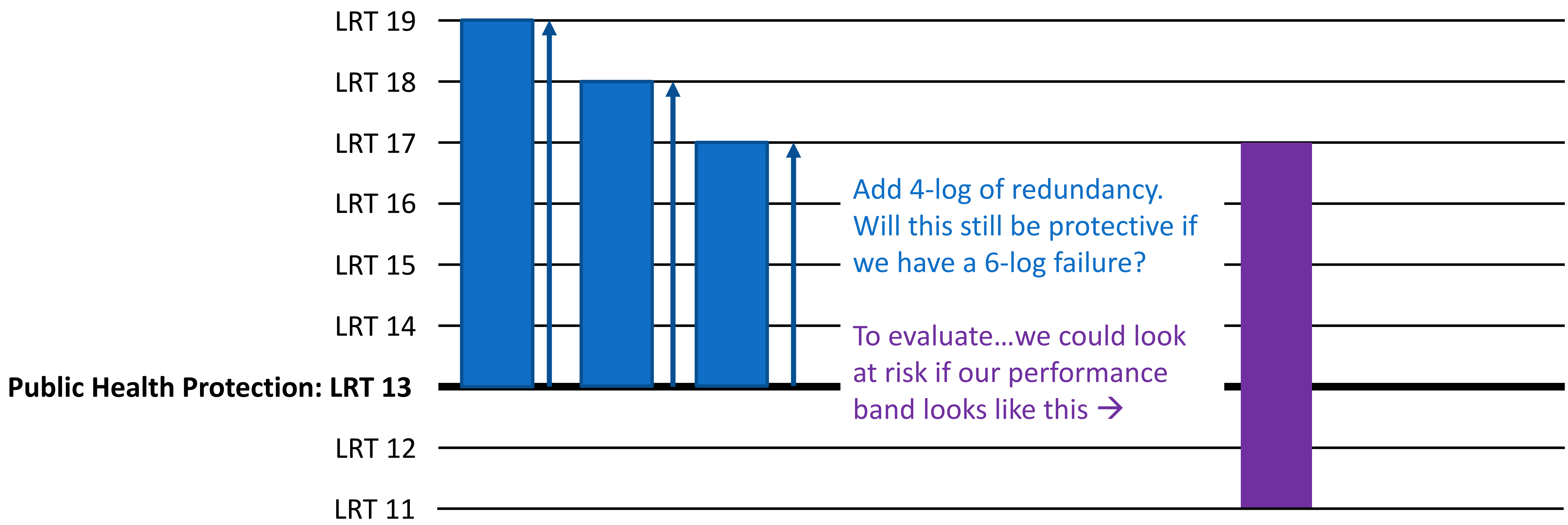
- Minimum treatment for public health protection: LRT = 13
- Minimum redundancy needed to address failures: +5 logs
  - 5-log buffer protective against a conservative 6-log failure rate (1% occurrence)
  - 99% compliance with daily risk goal
  - >99% with annual risk goal (< once in 100 years)
- Proposed compliance requirements for LRTs:
  - 18 LRT – 90%
  - 15 LRT – 9%
  - **13 LRT – 1%**

What are the criteria? (5-log redundancy)





Approach for Evaluating Redundancy

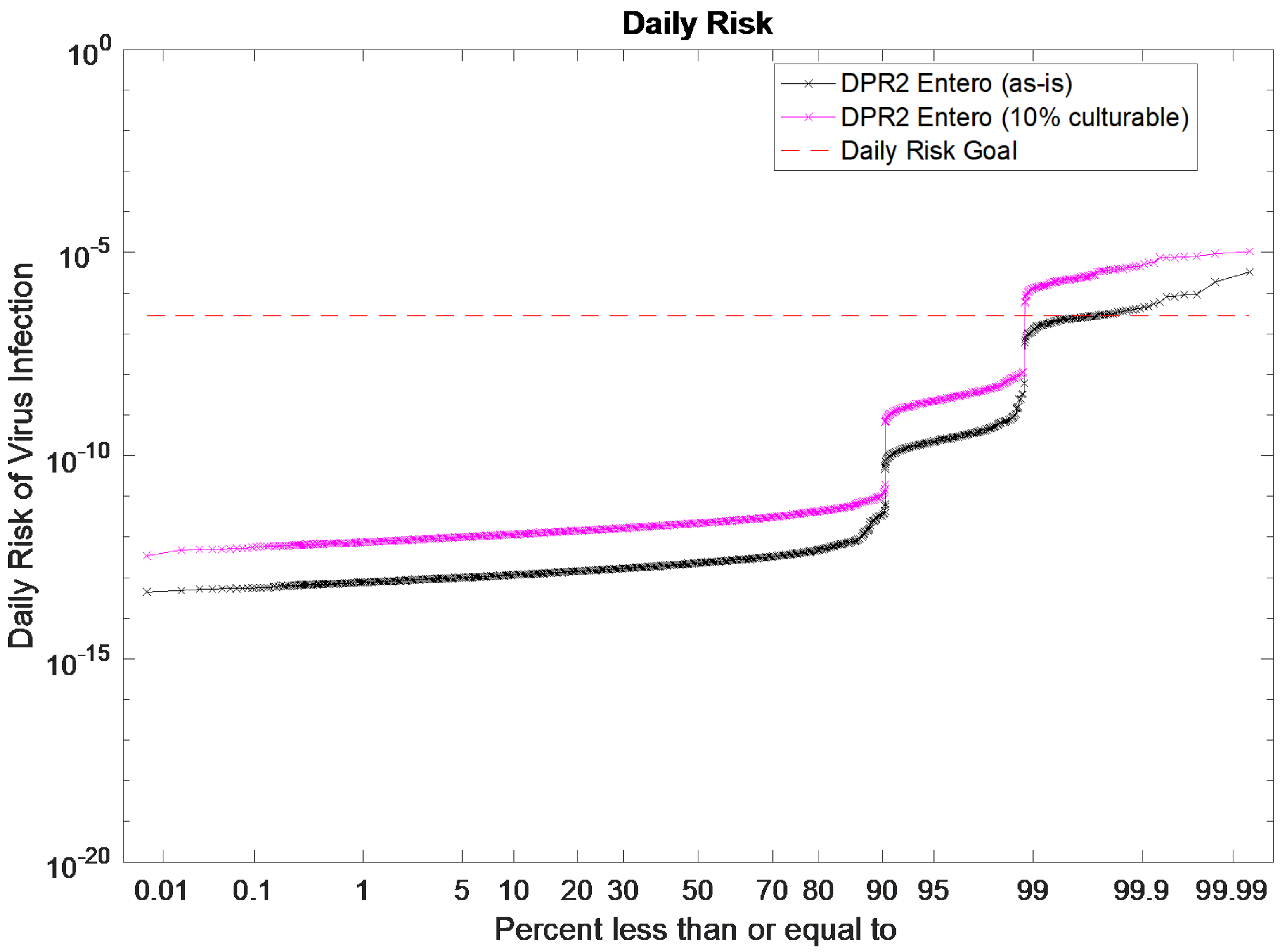


Evaluating Risk – Performance Assumption

- Treatment goals: 13 LRT + 4 LRT redundancy = 17
- Model includes intermediate and complete failure scenarios
  - 17 LRT – 90% -- performance typically at design conditions (13 + 4)
  - 14 LRT – 9% -- periods with lower redundancy (13 + 1)
  - 11 LRT – 1% -- full 6-log failure occurring 1% of the time (17 – 6)
- DDW assumed one 15-min, 6-log failure occurring 1x/year
  - 1% is more conservative than DDW assumption (0.003%)

Virus Comparison – Daily Risk

11 LRT – 1%
14 LRT – 9%
17 LRT – 90%

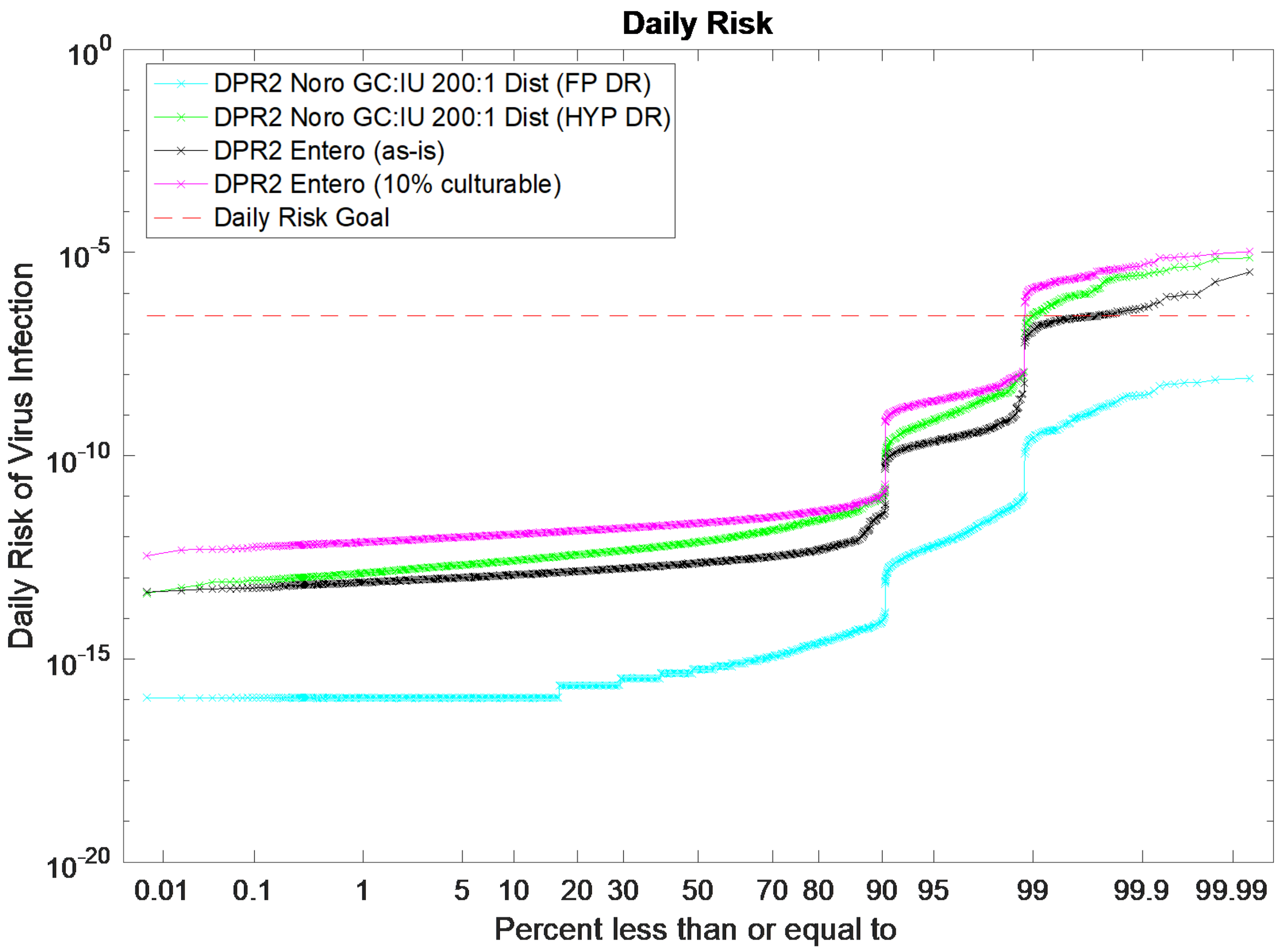


Entero – 10% culturable

Entero – no adjustment

Virus Comparison – Daily Risk

11 LRT – 1%
14 LRT – 9%
17 LRT – 90%

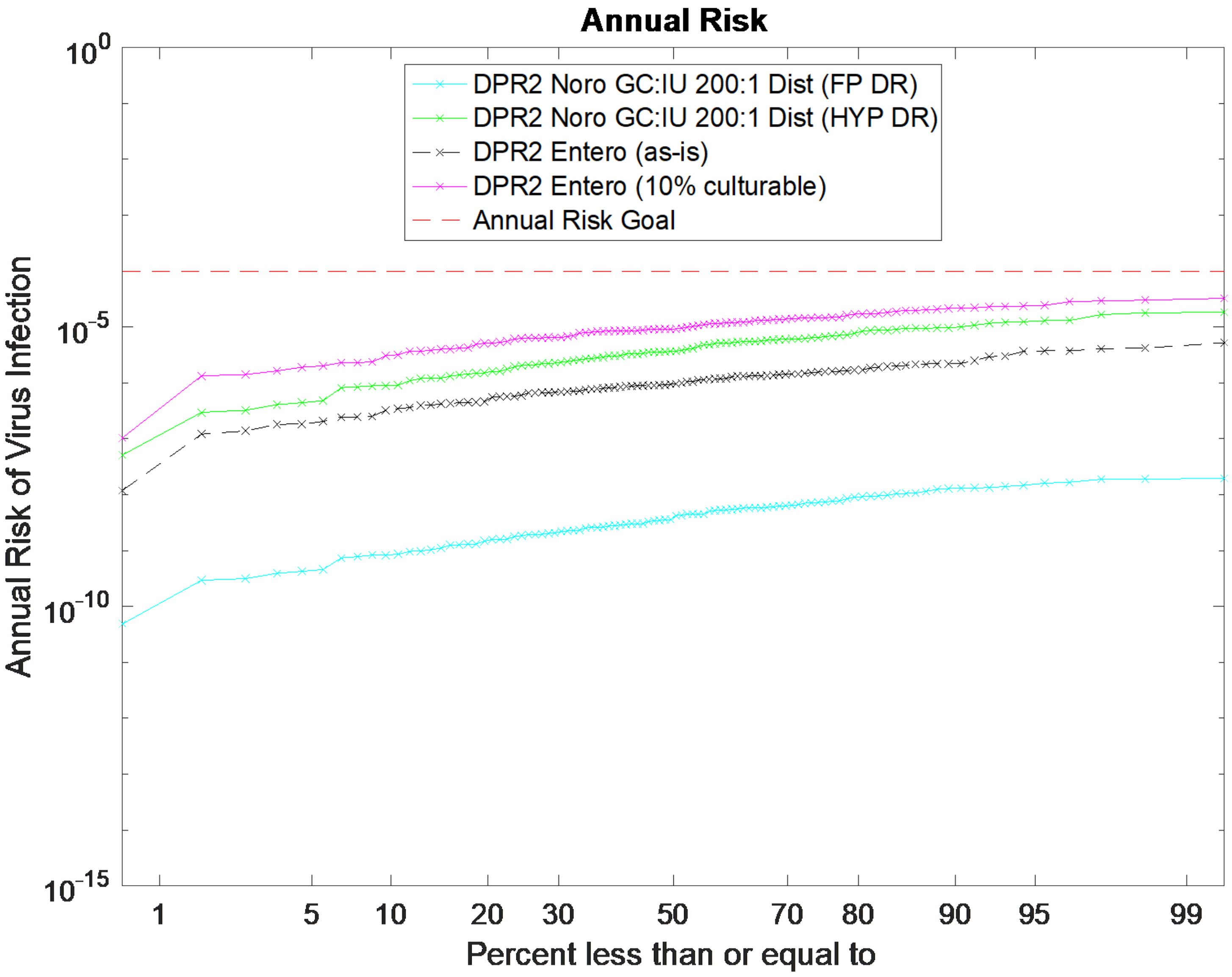


Entero – 10% culturable
NoV – hypergeometric
Entero – no adjustment

NoV – fractional Poisson

Virus Comparison – Annual Risk

11 LRT – 1%
14 LRT – 9%
17 LRT – 90%

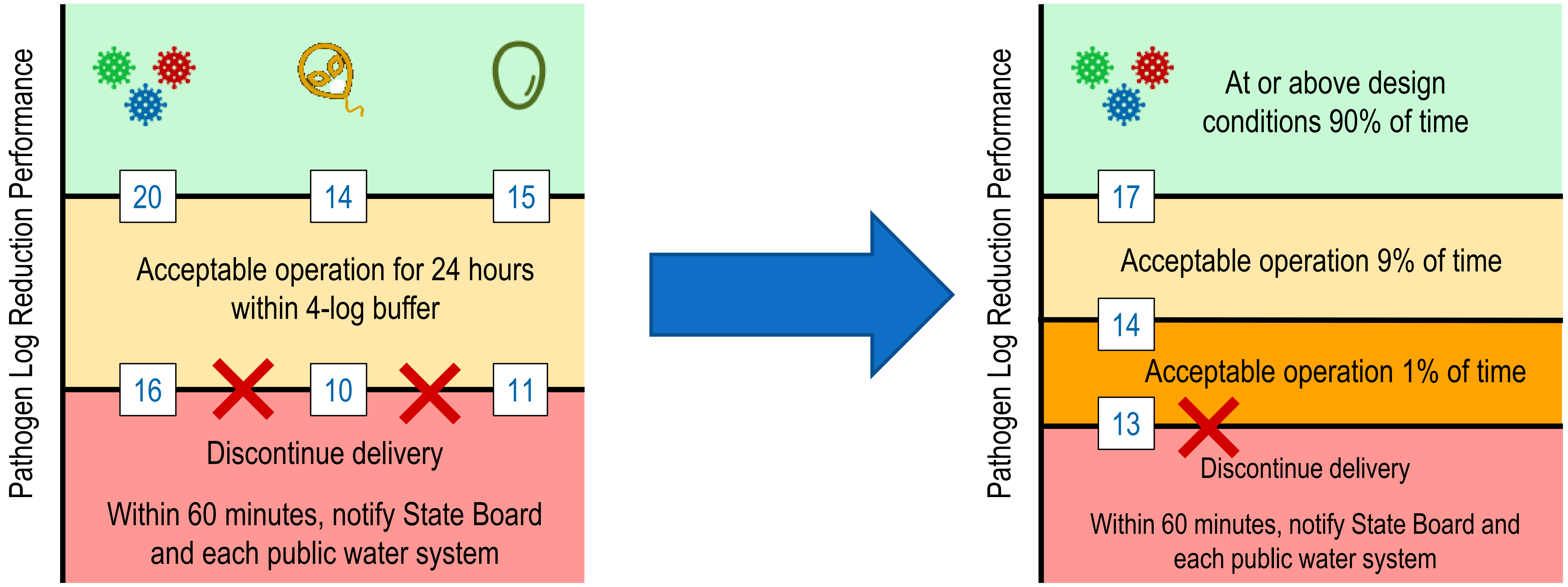


Entero – 10% culturable
NoV – hypergeometric
Entero – no adjustment
NoV – fractional Poisson

Potential Virus Requirements

- Minimum treatment for public health protection: LRT = 13
- Minimum redundancy needed to address failures: +4 logs
  - 4-log buffer protective against a conservative 6-log failure rate (1% occurrence)
  - 99% compliance with daily risk goal
  - >99% with annual risk goal (< once in 100 years)
- Proposed compliance requirements for LRTs:
  - 17 LRT – 90%
  - 14 LRT – 9%
  - **13 LRT – 1%**

What are the criteria? (4-log redundancy)

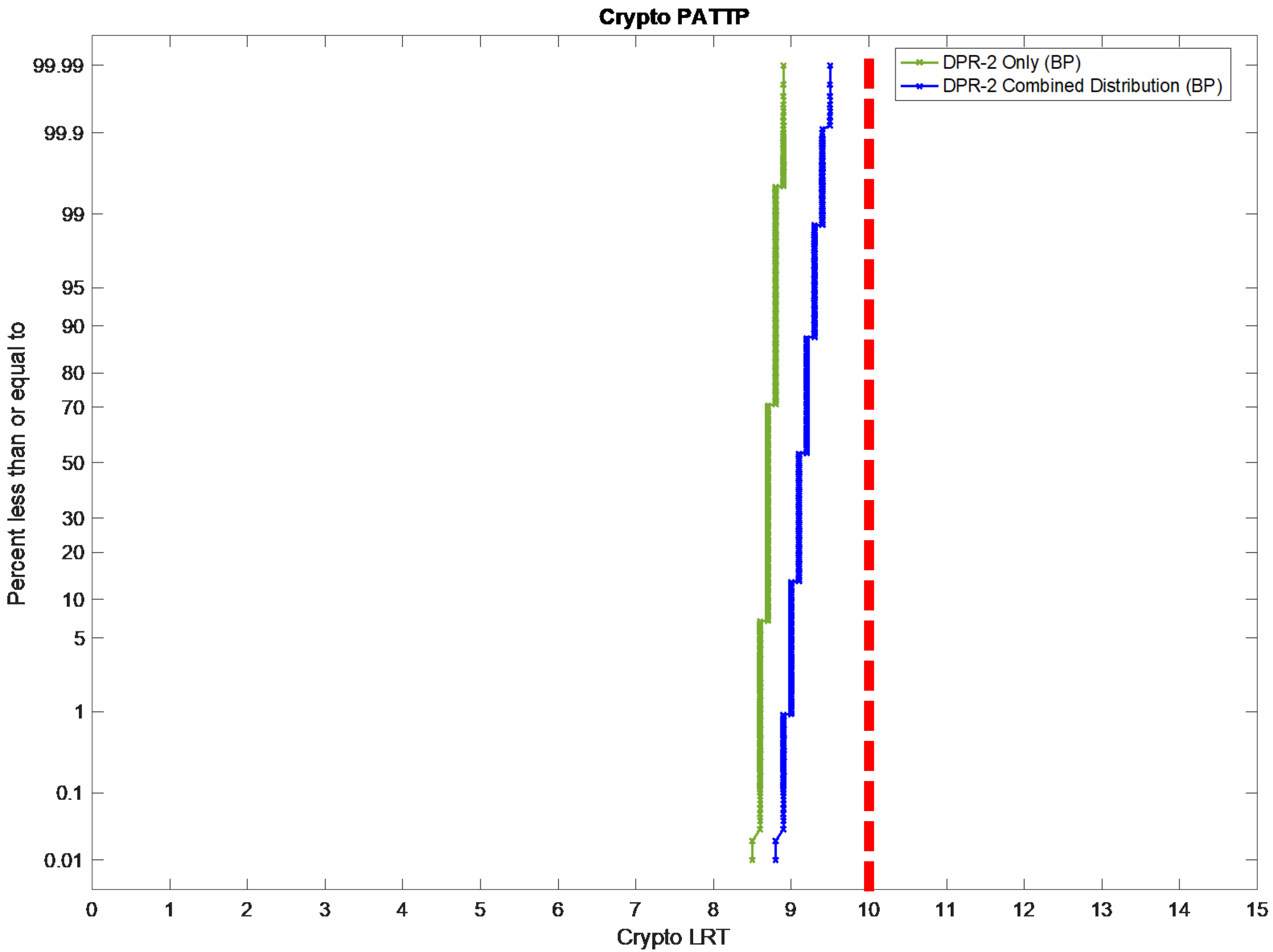


Crypto

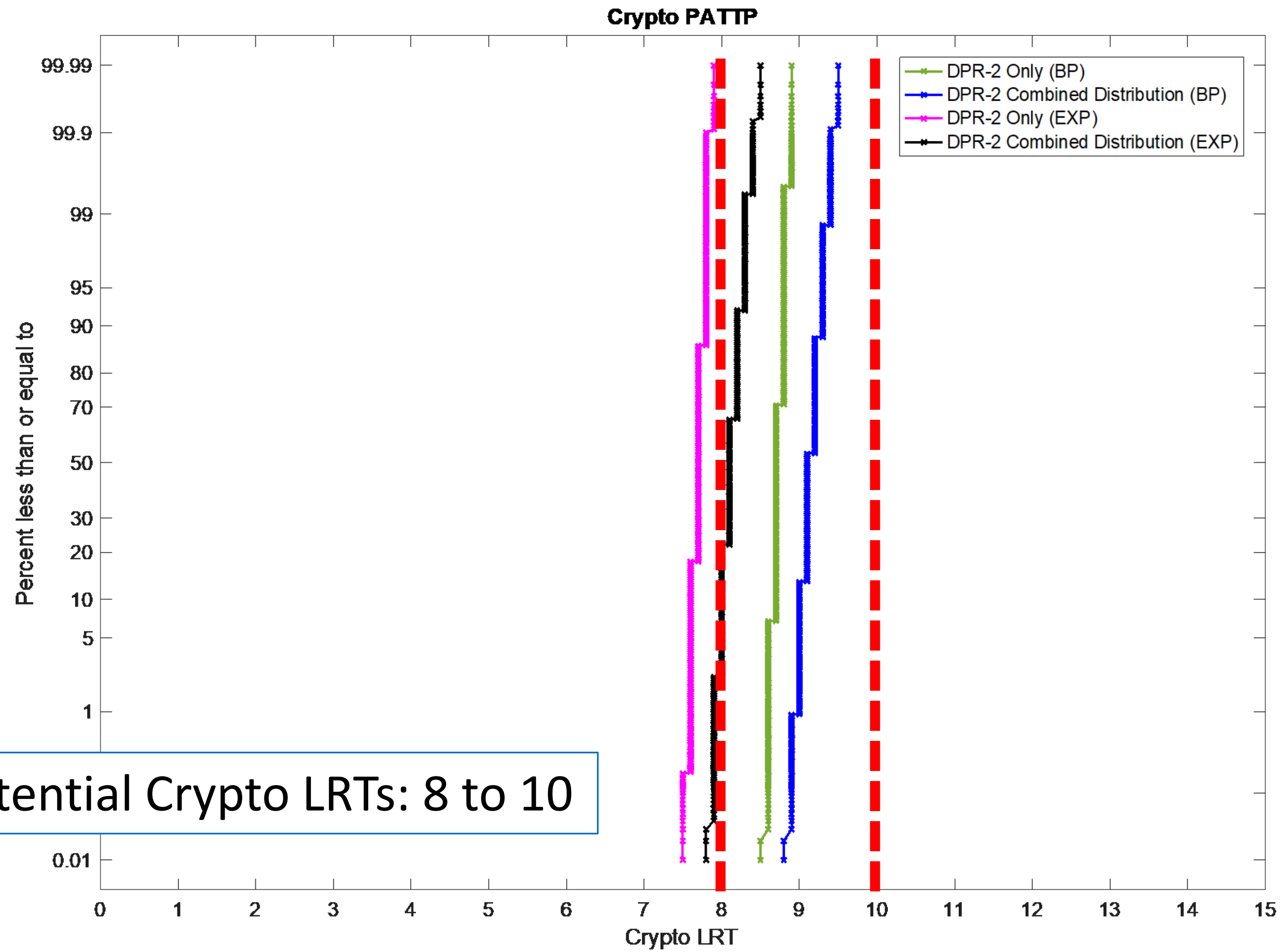
Crypto

- Raw WW:
  - DPR-2 Distribution: μ_{log} = 1.7; σ_{log} = 0.4
  - DPR-2 Distribution: μ_{log} = 1.9; σ_{log} = 0.6 (combined DPR-2)
- D-R
  - Beta-Poisson (Messner et al. 2016)
  - Exponential (US EPA 2005)

Crypto Required LRTs (Beta-Poisson D-R)

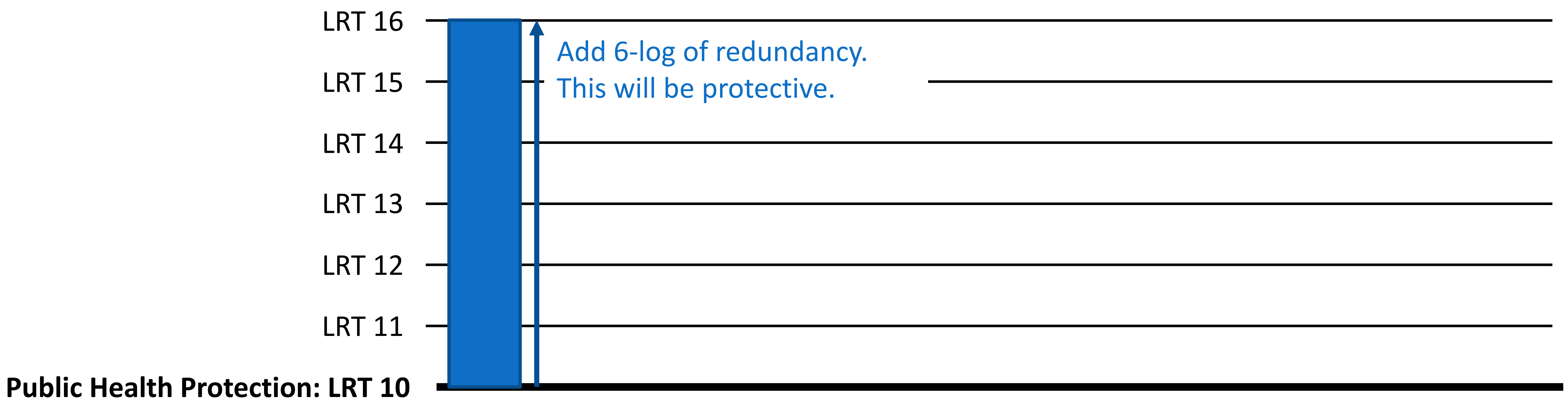


Crypto Required LRTs (Exponential D-R)

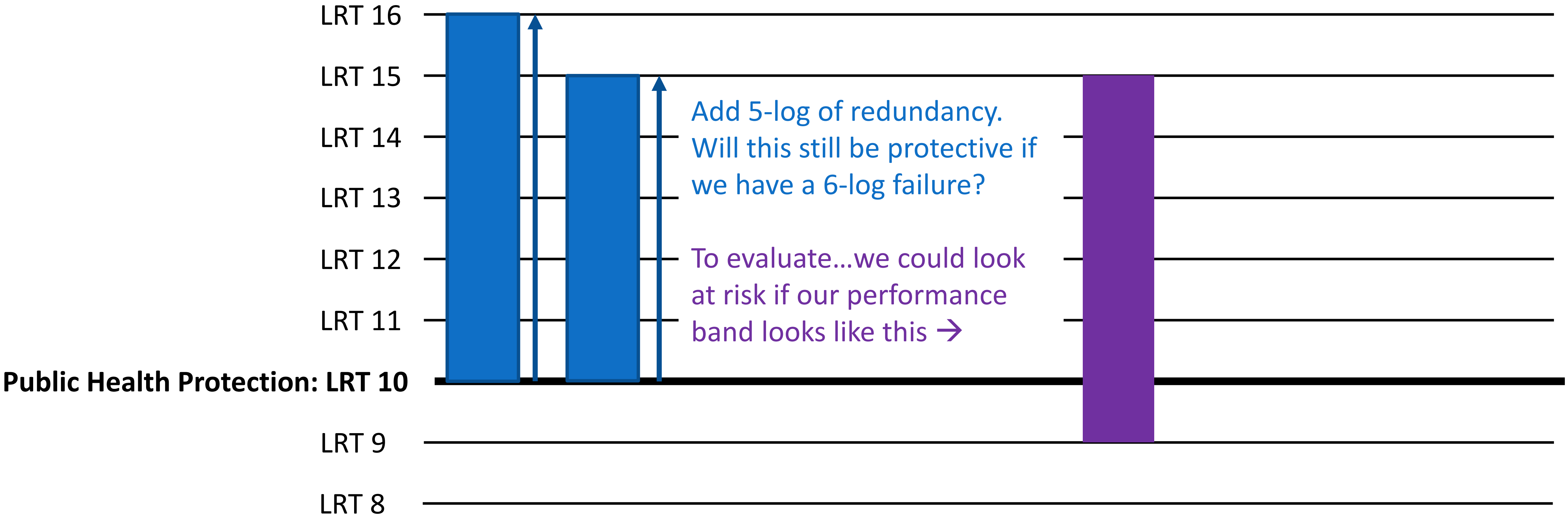


Range of potential Crypto LRTs: 8 to 10

Approach for Evaluating Redundancy



Approach for Evaluating Redundancy

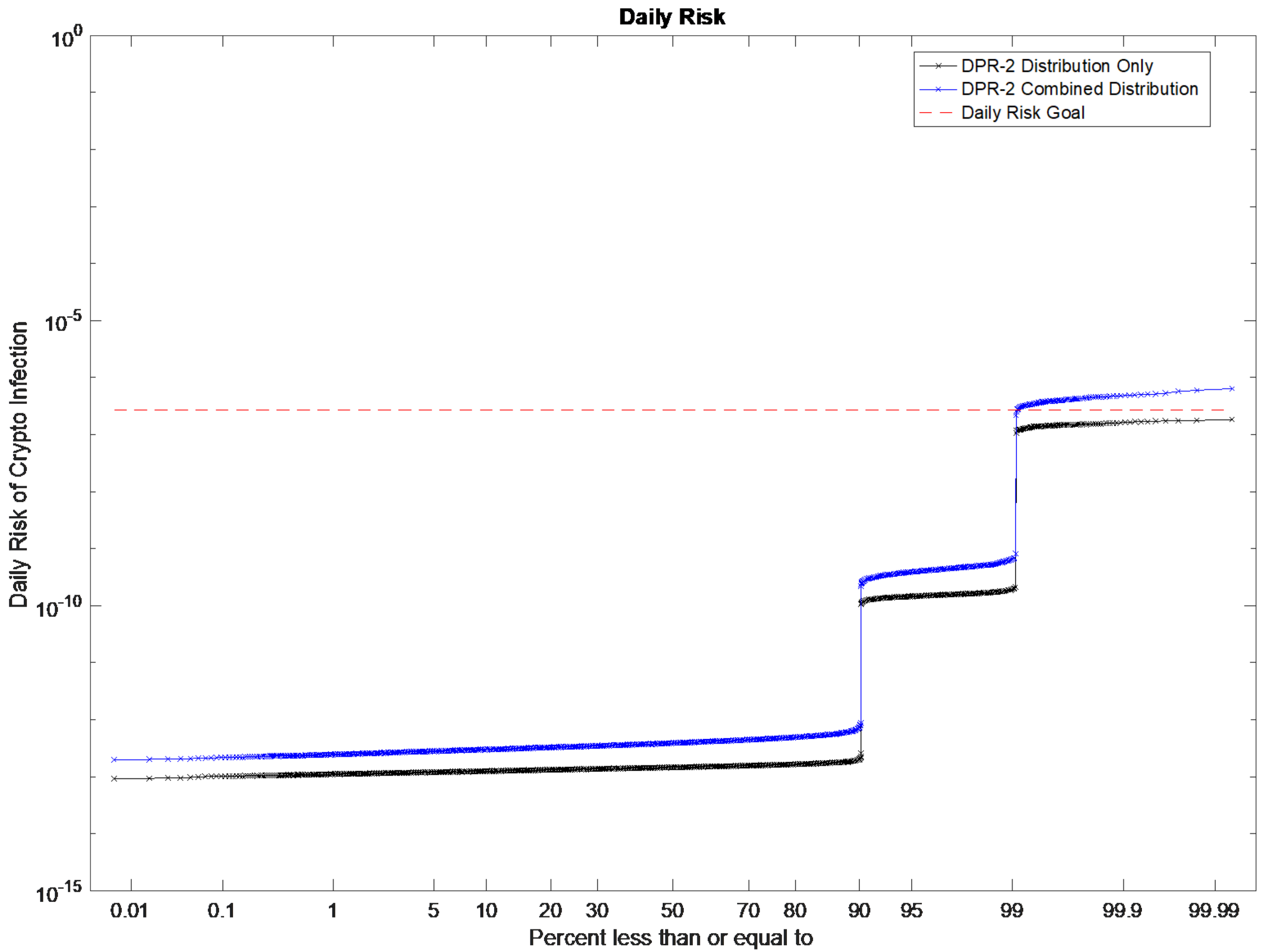


Evaluating Risk – Performance Assumption

- Treatment goals: 10 LRT + 5 LRT redundancy = 15
- Model includes intermediate and complete failure scenarios
  - 15 LRT – 90% -- performance typically at design conditions (10 + 5)
  - 12 LRT – 9% -- periods with lower redundancy (10 + 2)
  - 9 LRT – 1% -- full 6-log failure occurring 1% of the time (15 – 6)
- DDW assumed one 15-min, 6-log failure occurring 1x/year
  - 1% is more conservative than DDW assumption (0.003%)

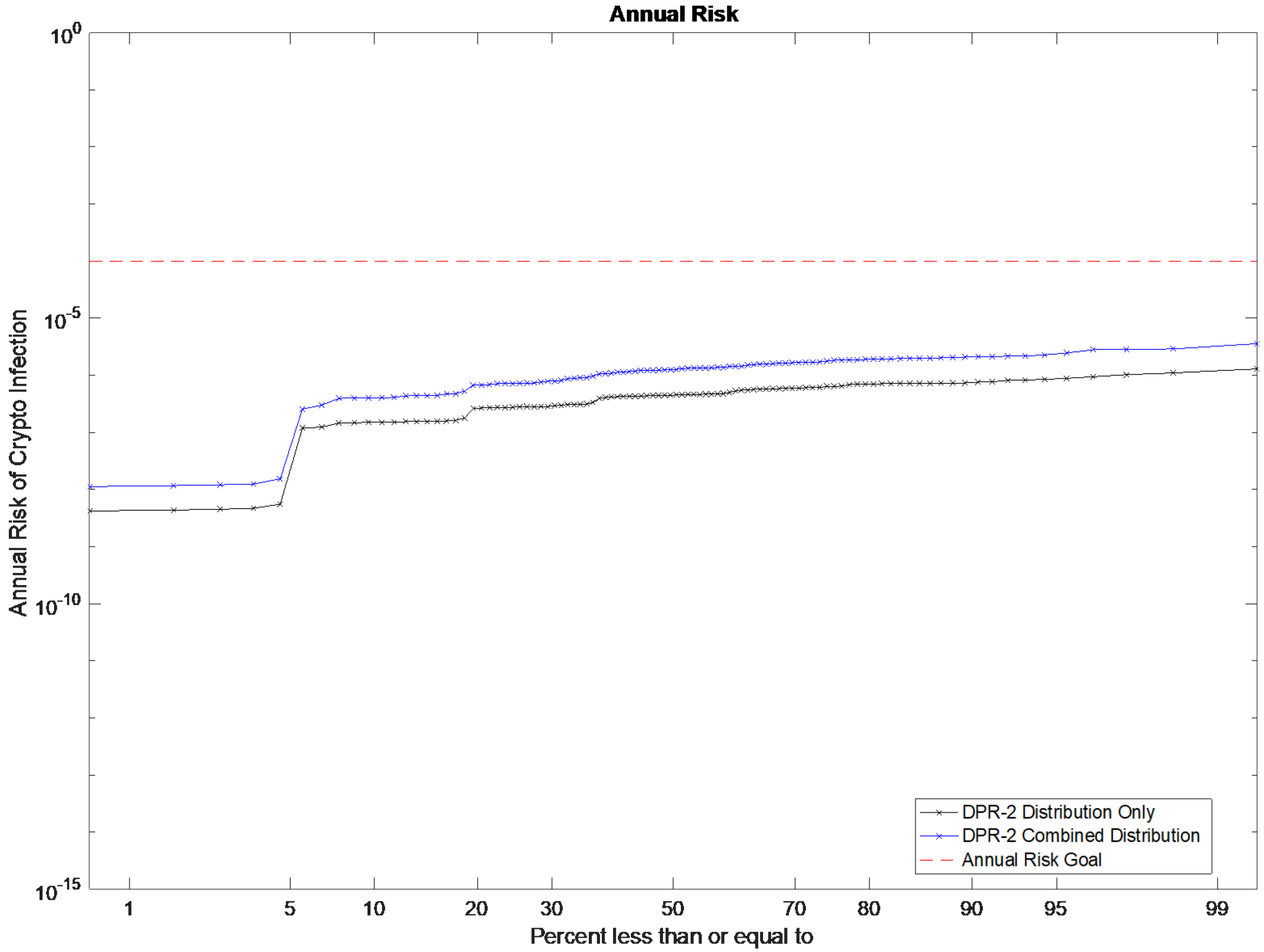
Crypto – Daily Risk with 5-log redundancy

9 LRT – 1%
12 LRT – 9%
15 LRT – 90%



Crypto – Annual Risk with 5-log redundancy

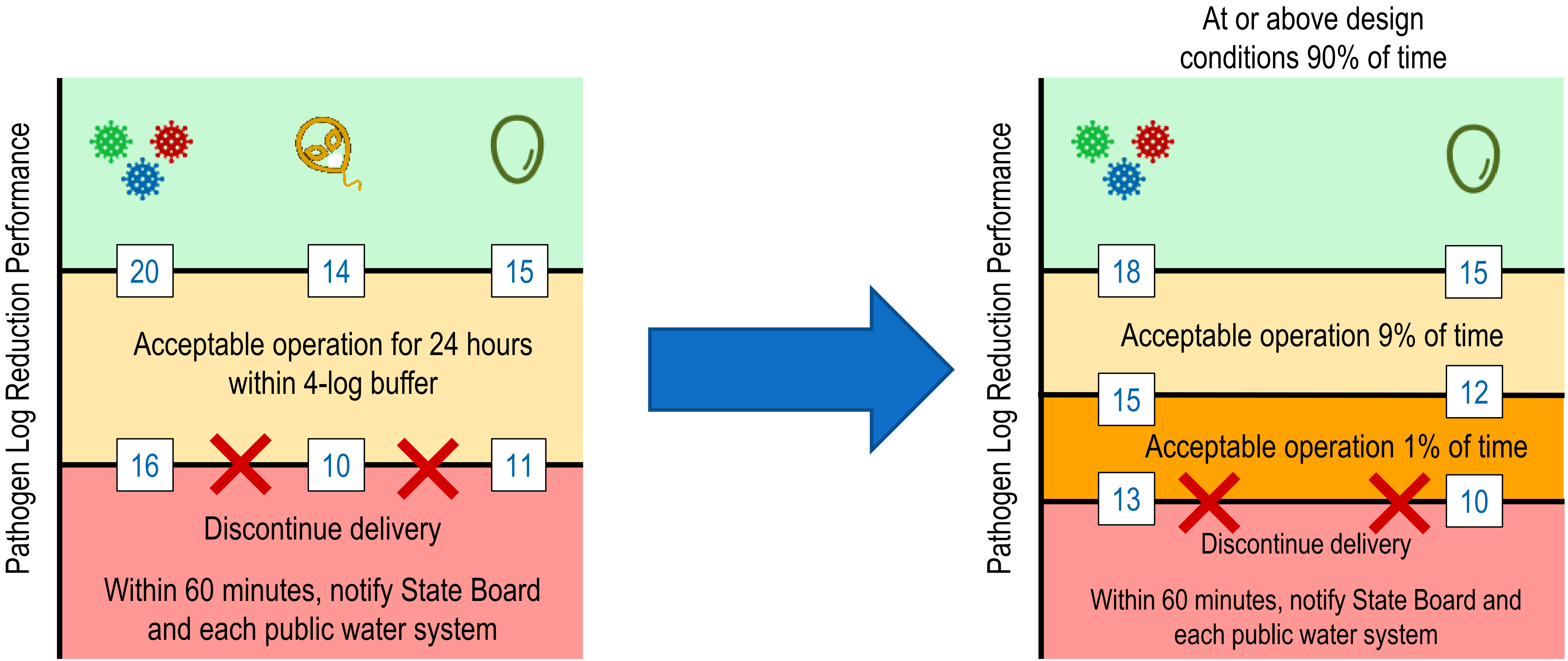
9 LRT – 1%
12 LRT – 9%
15 LRT – 90%



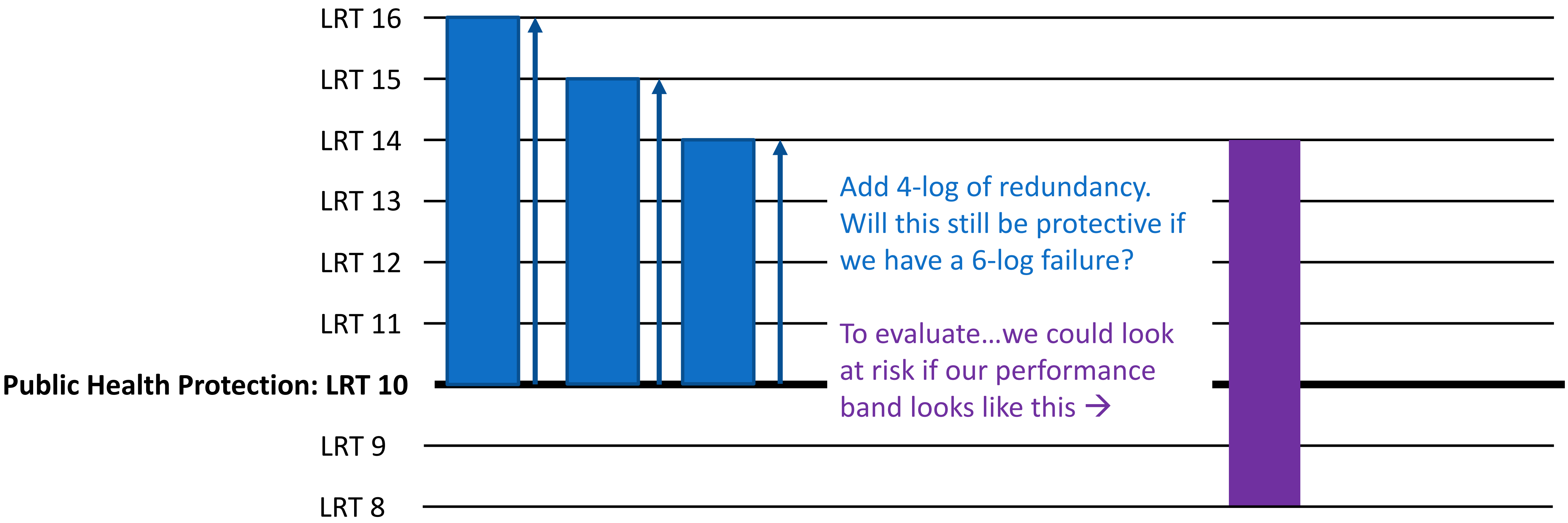
Potential Crypto Requirements

- Minimum treatment for public health protection: LRT = 10
- Minimum redundancy needed to address failures: +5 logs
  - 5-log buffer protective against a conservative 6-log failure rate (1% occurrence)
  - 99% compliance with daily risk goal
  - >99% with annual risk goal (< once in 100 years)
- Proposed compliance requirements for LRTs:
  - 15 LRT – 90%
  - 12 LRT – 9%
  - **10 LRT – 1%**

What are the criteria? (5-log redundancy)



Approach for Evaluating Redundancy

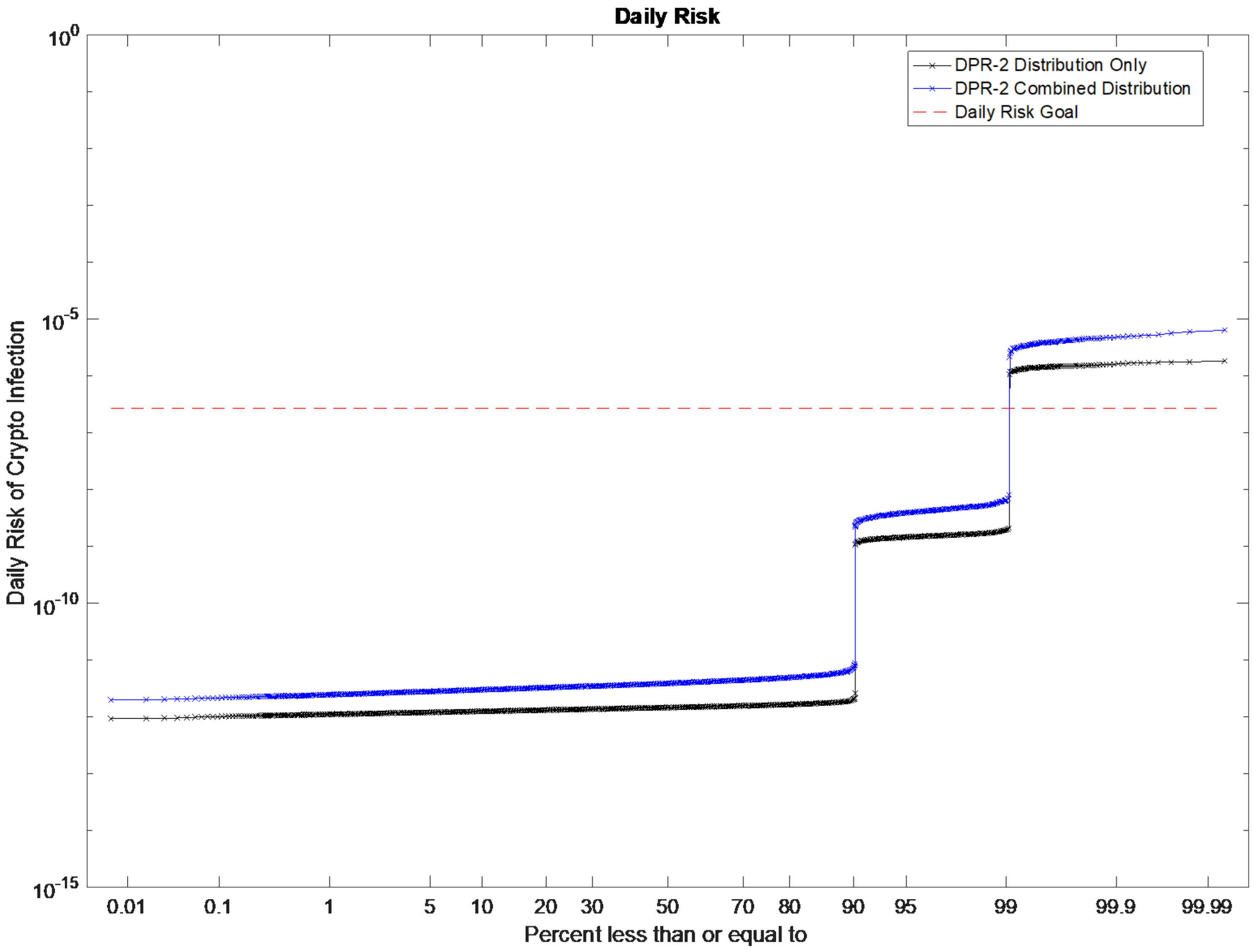


Evaluating Risk – Performance Assumption

- Treatment goals: 10 LRT + 4 LRT redundancy = 14
- Model includes intermediate and complete failure scenarios
  - 14 LRT – 90% -- performance typically at design conditions (10 + 4)
  - 11 LRT – 9% -- periods with lower redundancy (10 + 1)
  - 8 LRT – 1% -- full 6-log failure occurring 1% of the time (14 – 6)
- DDW assumed one 15-min, 6-log failure occurring 1x/year
  - 1% is more conservative than DDW assumption (0.003%)

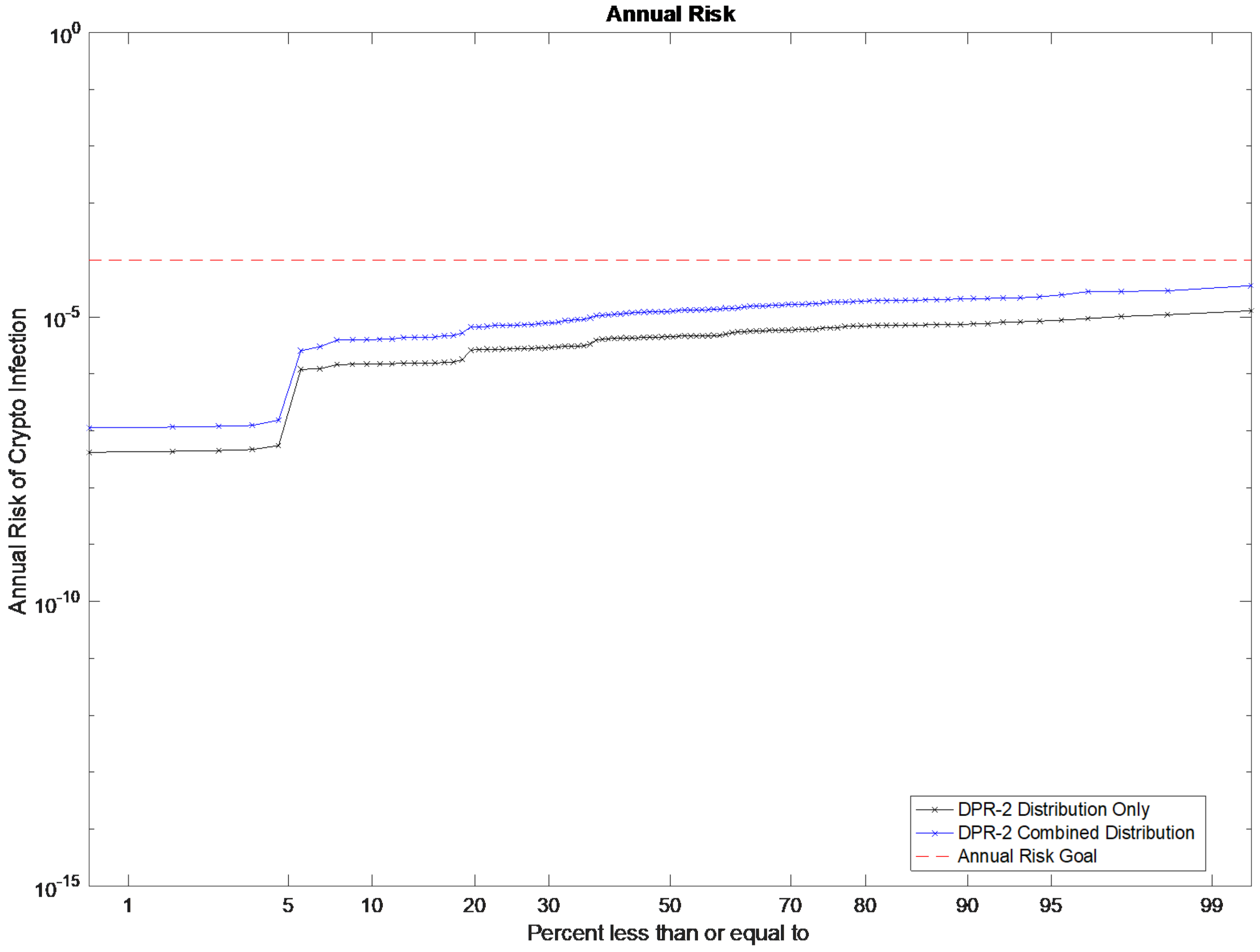
Crypto – Daily Risk with 4-log redundancy

8 LRT – 1%
11 LRT – 9%
14 LRT – 90%



Crypto – Annual Risk with 4-log redundancy

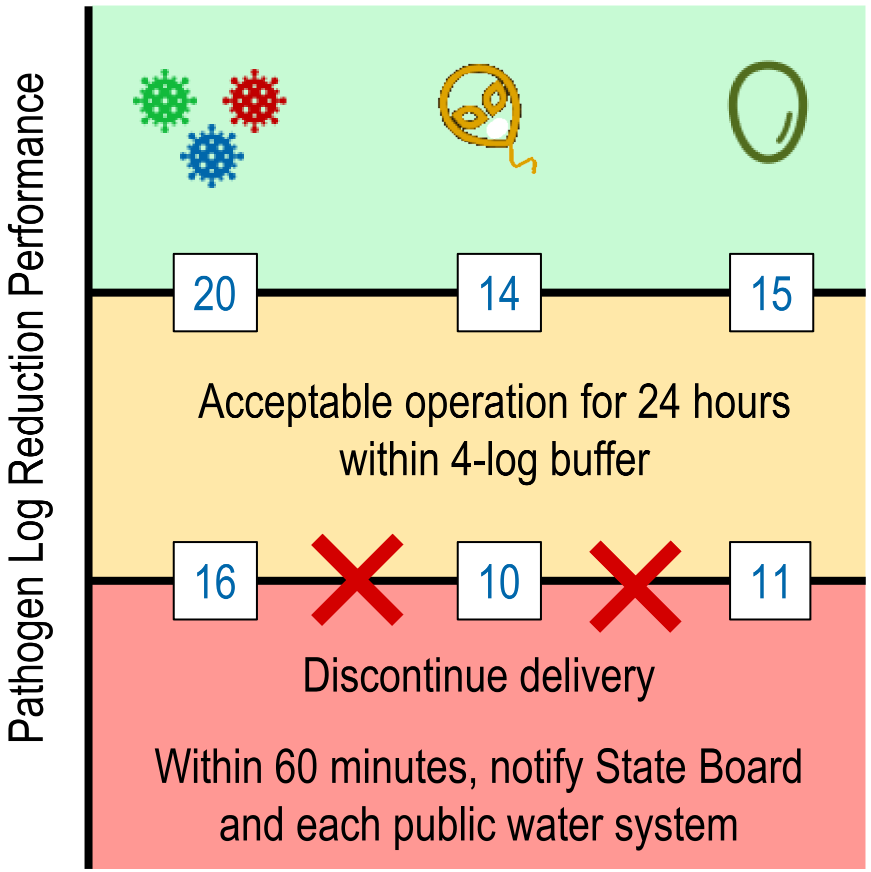
8 LRT – 1%
11 LRT – 9%
14 LRT – 90%

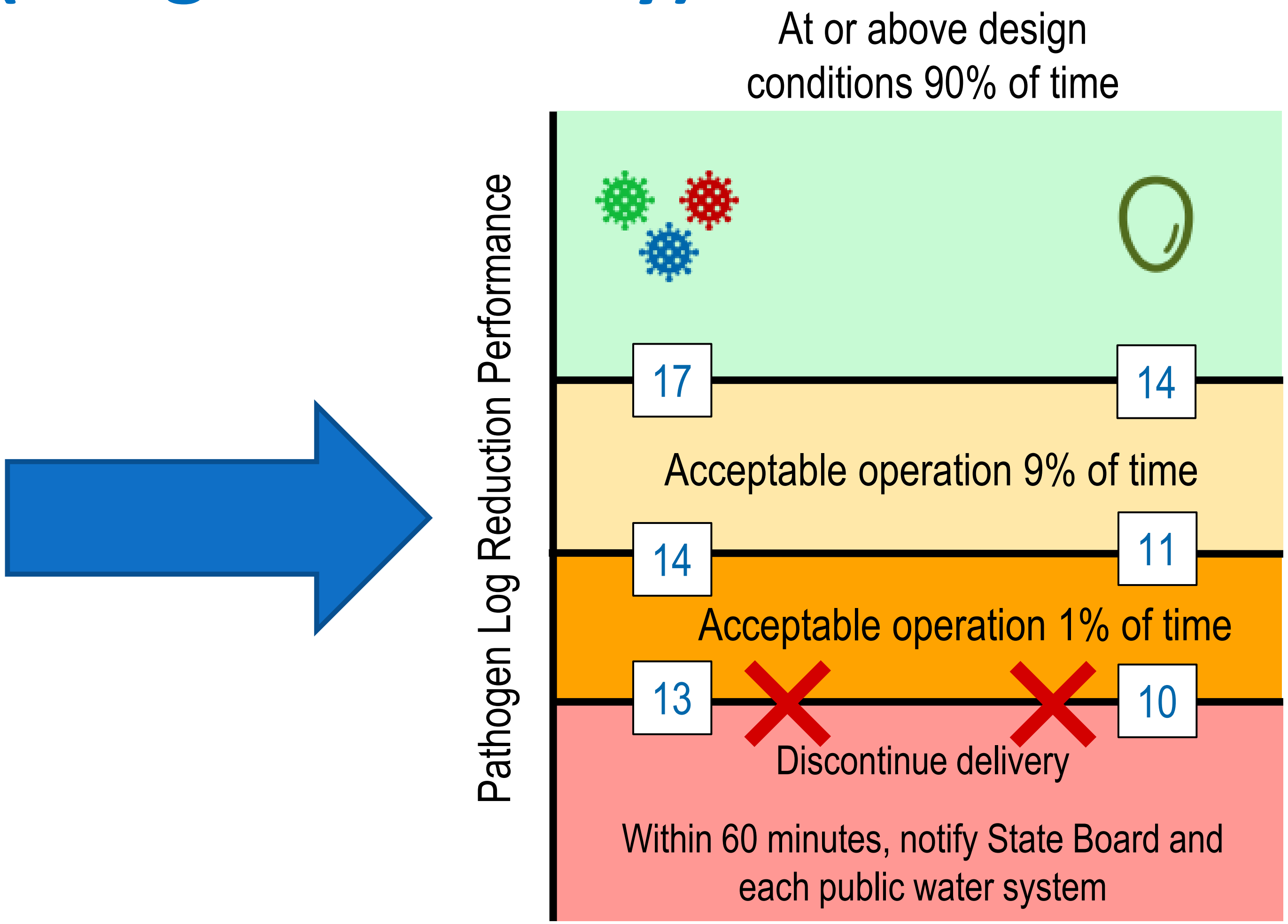


Potential Crypto Requirements

- Minimum treatment for public health protection: LRT = 10
- Minimum redundancy needed to address failures: +4 logs
  - 4-log buffer protective against a conservative 6-log failure rate (1% occurrence)
  - 99% compliance with daily risk goal
  - >99% with annual risk goal (< once in 100 years)
- Proposed compliance requirements for LRTs:
  - 14 LRT – 90%
  - 11 LRT – 9%
  - **10 LRT – 1%**

What are the criteria? (4-log redundancy)



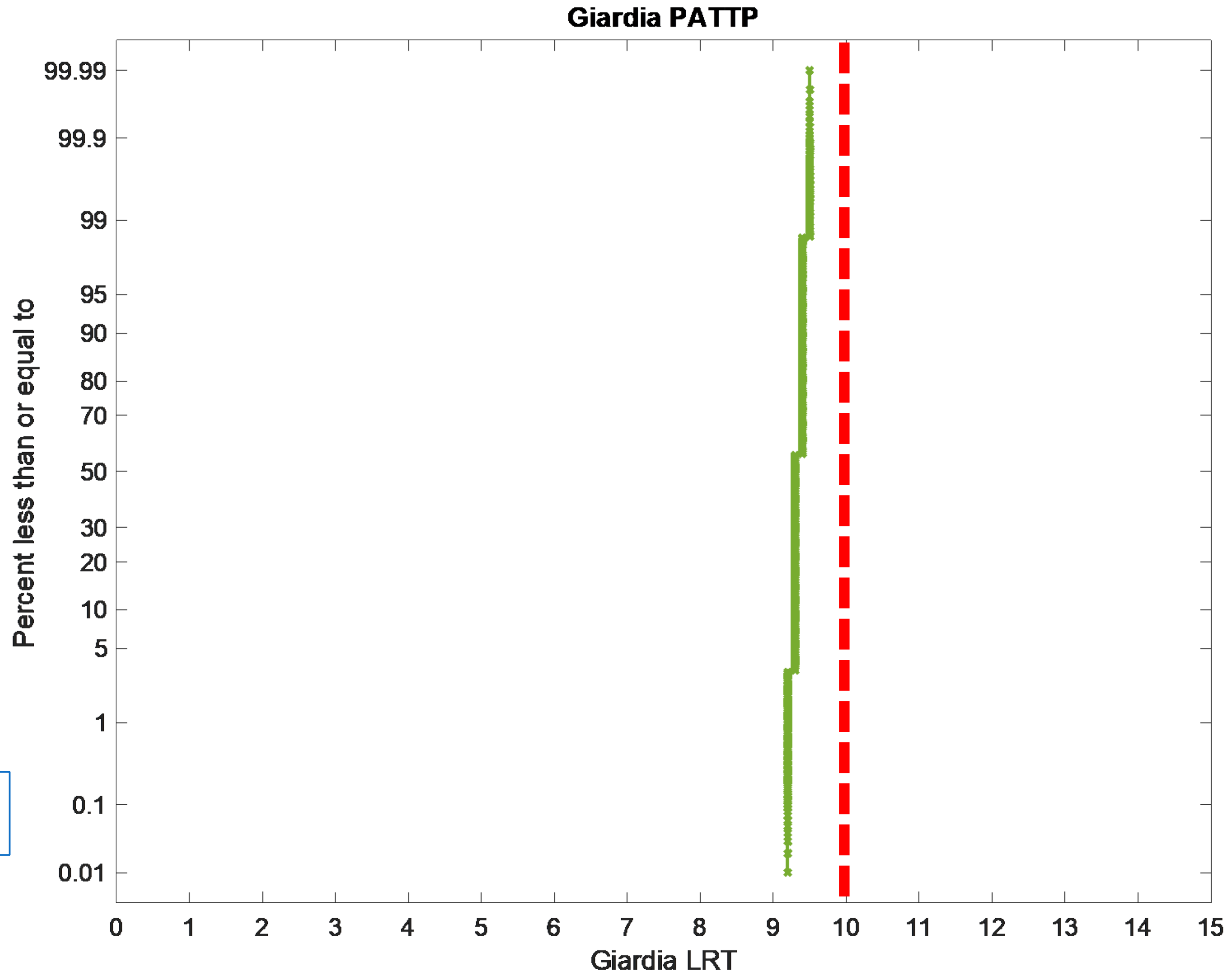


Giardia

Giardia Assumptions

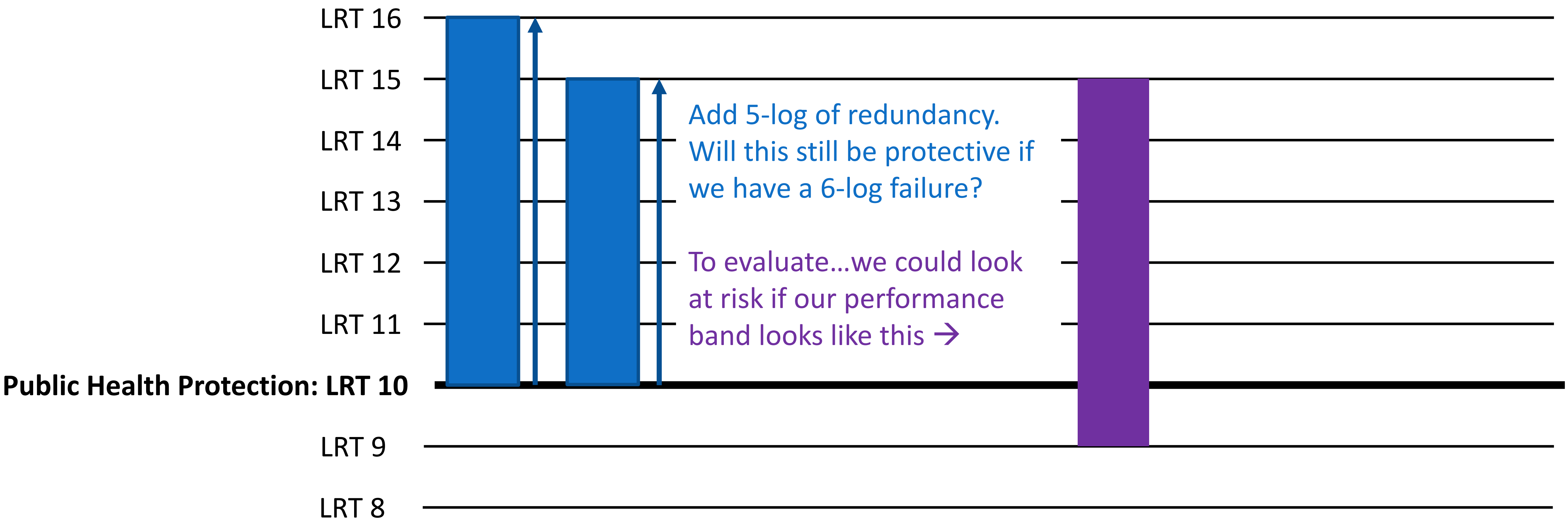
- Raw WW:
  - DPR-2 Distribution: $\mu_{log} = 4.0$; $\sigma_{log} = 0.4$
- D-R
  - Exponential (Regli et al. 1991)

Giardia Required LRTs



Giardia LRT: 10

Approach for Evaluating Redundancy

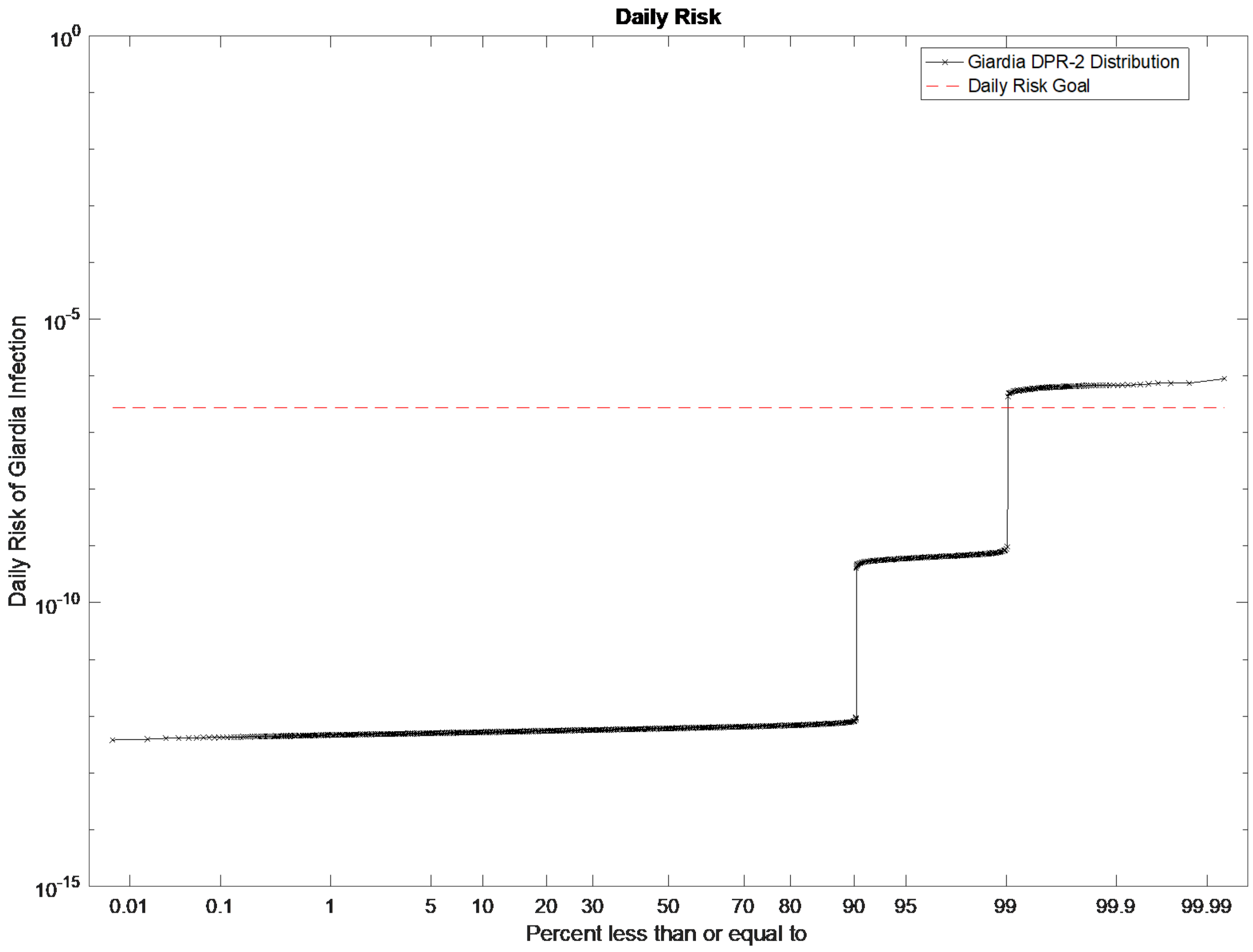


Evaluating Risk – Performance Assumption

- Treatment goals: 10 LRT + 5 LRT redundancy = 15
- Model includes intermediate and complete failure scenarios
  - 15 LRT – 90% -- performance typically at design conditions (10 + 5)
  - 12 LRT – 9% -- periods with lower redundancy (10 + 2)
  - 9 LRT – 1% -- full 6-log failure occurring 1% of the time (15 – 6)
- DDW assumed one 15-min, 6-log failure occurring 1x/year
  - 1% is more conservative than DDW assumption (0.003%)

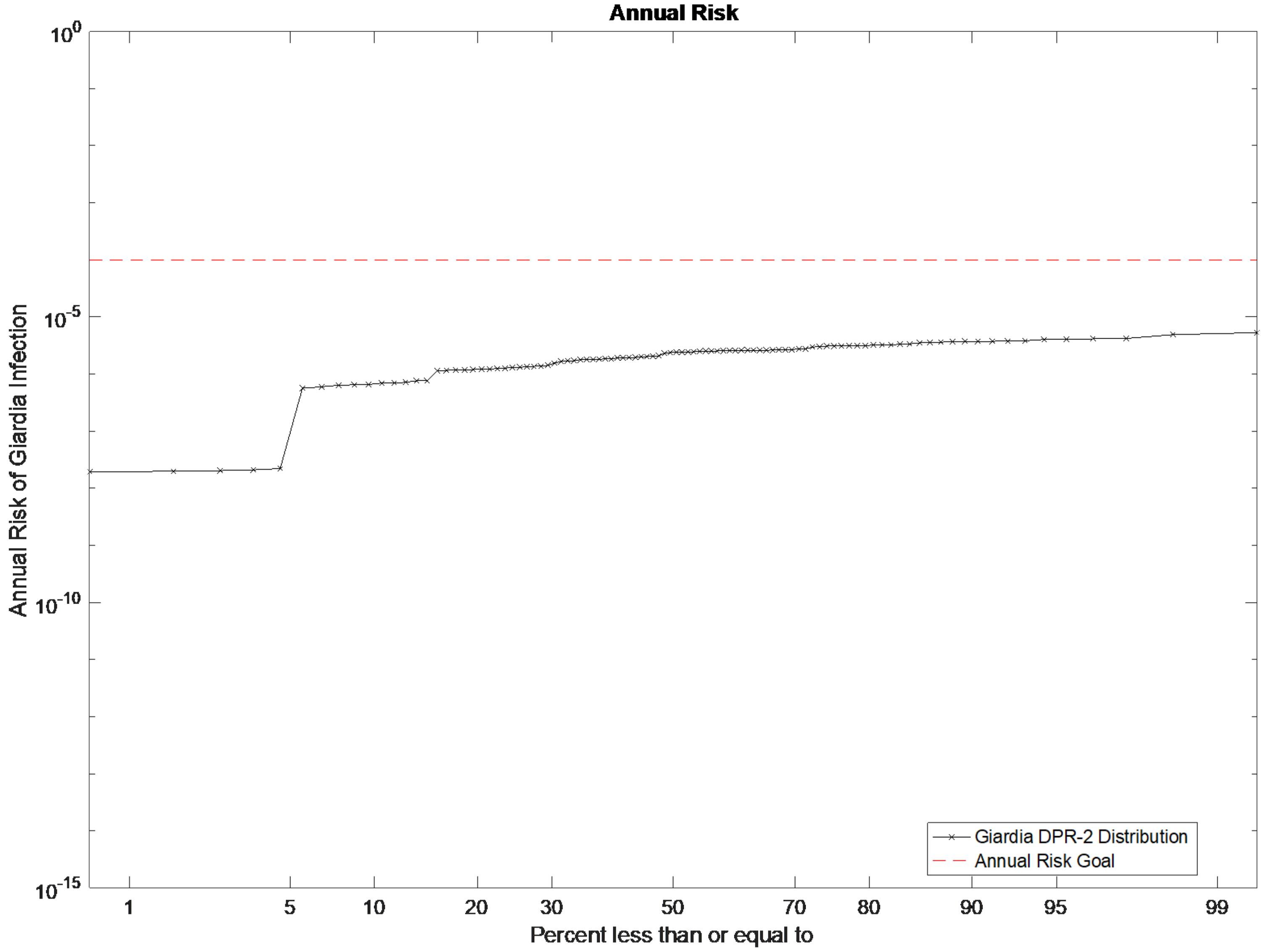
Giardia – Daily Risk with 5-log redundancy

9 LRT – 1%
12 LRT – 9%
15 LRT – 90%



Giardia – Annual Risk with 5-log redundancy

9 LRT – 1%
12 LRT – 9%
15 LRT – 90%



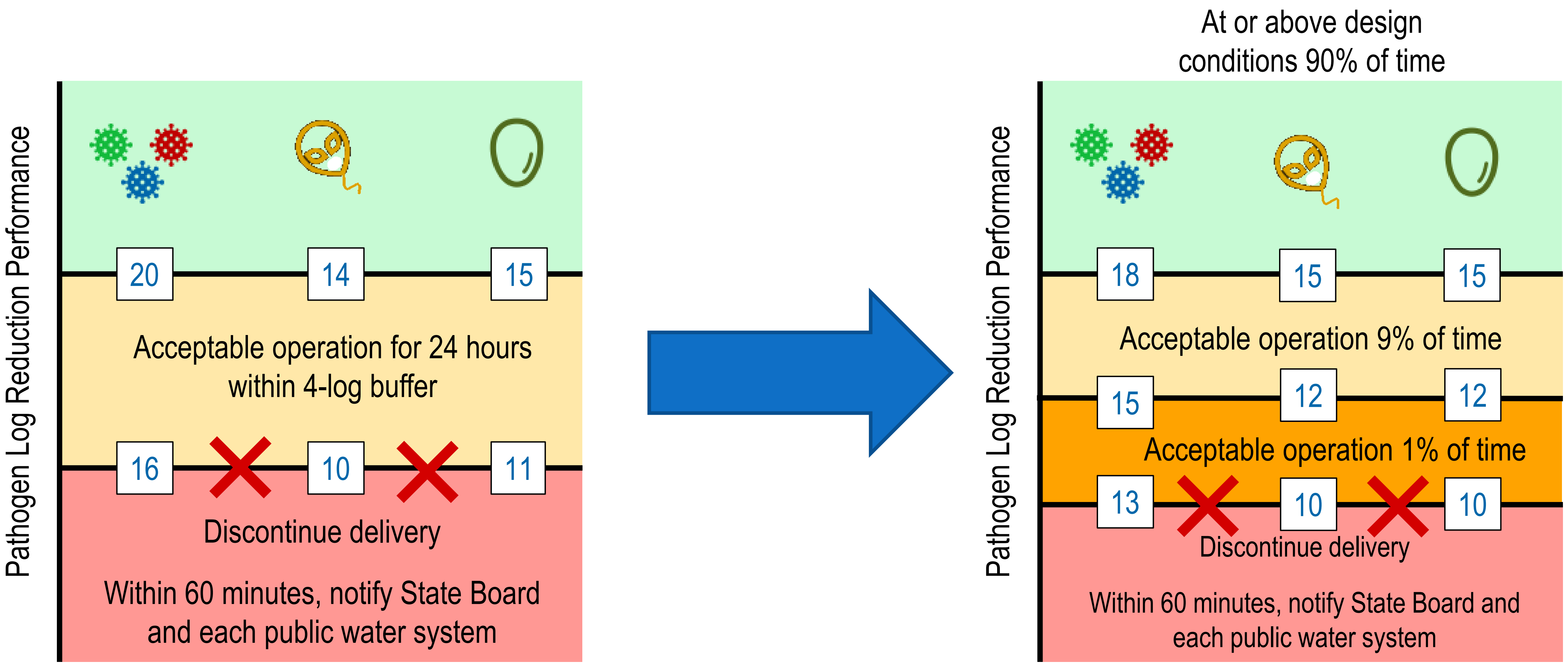
Potential Giardia Requirements

- Minimum treatment for public health protection: LRT = 10
- Minimum redundancy needed to address failures: +5 logs
  - 5-log buffer protective against a conservative 6-log failure rate (1% occurrence)
  - 99% compliance with daily risk goal
  - >99% with annual risk goal (< once in 100 years)
- Proposed compliance requirements for LRTs:
  - 15 LRT – 90%
  - 12 LRT – 9%
  - **10 LRT – 1%**

Suggested Recommendations

- The Panel recommends a probabilistic analysis utilizing the DPR -2 dataset rather than the static maximum point estimate approach for development of the LRVs
- While the current LRV criteria can be considered protective of public health, additional analysis is recommended to address potential overengineering treatment barriers and to conduct an intentional effort by DDW to require a reasonable number and combination of such barriers.
- The Panel probabilistic analysis identified alternative LRVs that adequately protect public health and are based on scientifically defensible assumptions.
- The Panel also suggests an alternative approach to address compliance with the LRVs that greatly simplifies the response time-based approach currently proposed.

Summary of proposed criteria with 5-log redundancy



Questions?