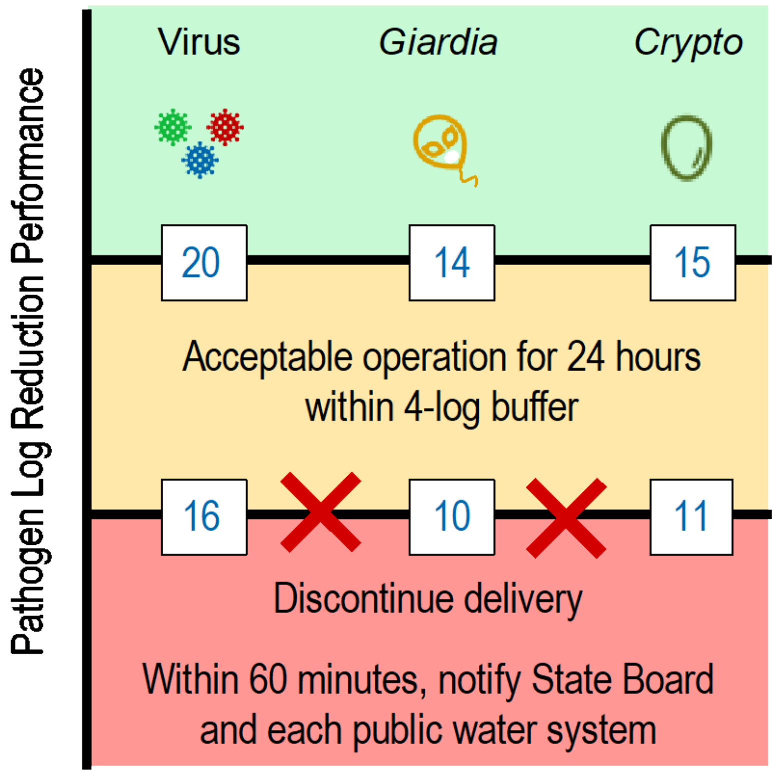
NWRI DPR Expert Panel – Pathogen Control

January 31, 2022

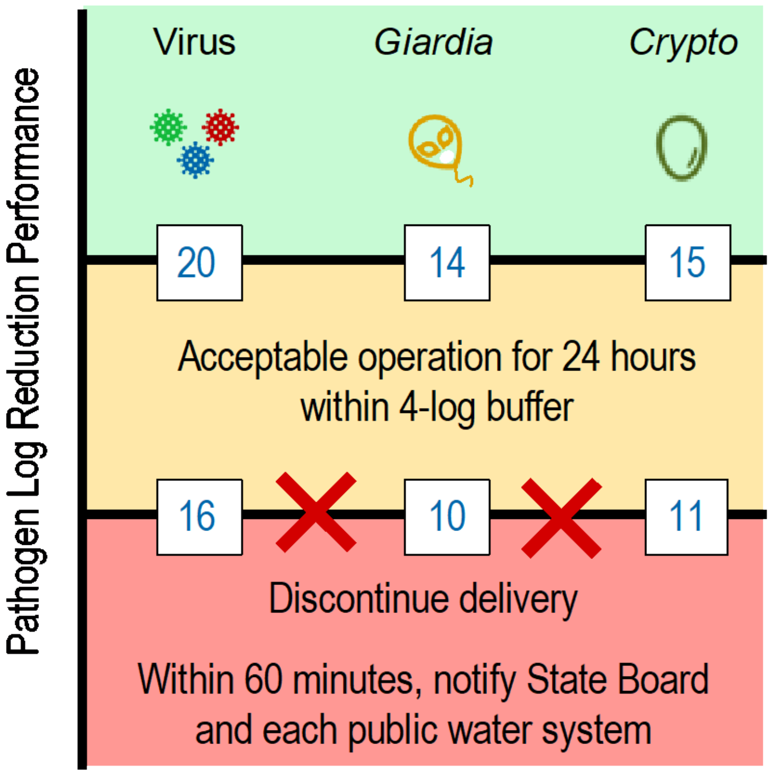
Discussion Topics

- Brief Review of DDW pathogen controls (LRVs and Compliance)
- Panel's preliminary (written) comments to DDW on draft criteria
- Update on results from Pathogen Workgroup discussions
- Proposed Panel comments and recommendations
- Next Steps

What are the DDW Pathogen Control criteria?



Topics to Evaluate

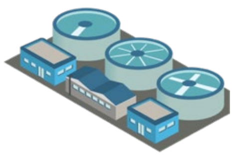


- Baseline LRT requirements
  - Which **organisms** should be used to set the log reduction targets (LRTs)?
  - What pathogen **datasets** should be used?
- Redundant LRTs and failures
  - What **failure assumptions** are reasonable?
- Compliance with LRTs
  - What is the right level of compliance with these treatment targets?

Calculating Risk

1. Exposure Assessment

Raw wastewater



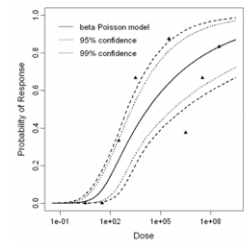
Treatment

Drinking water levels

Drinking water consumption

Exposure

2. Dose-Response



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?

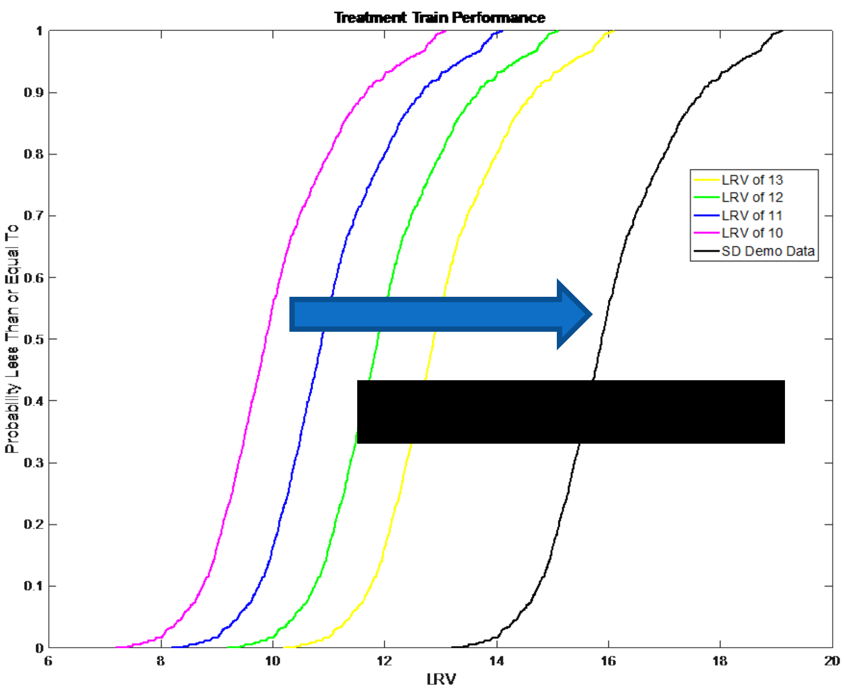
How much water do people drink?

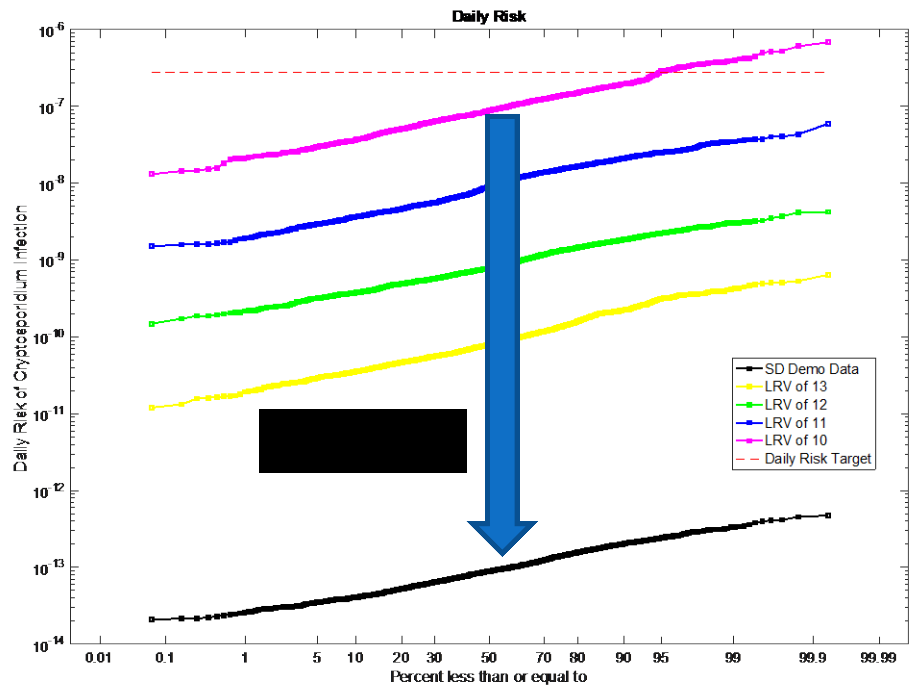
Which D-R functions to use?

What assumptions should we make to estimate risk?

Redundancy and Risk

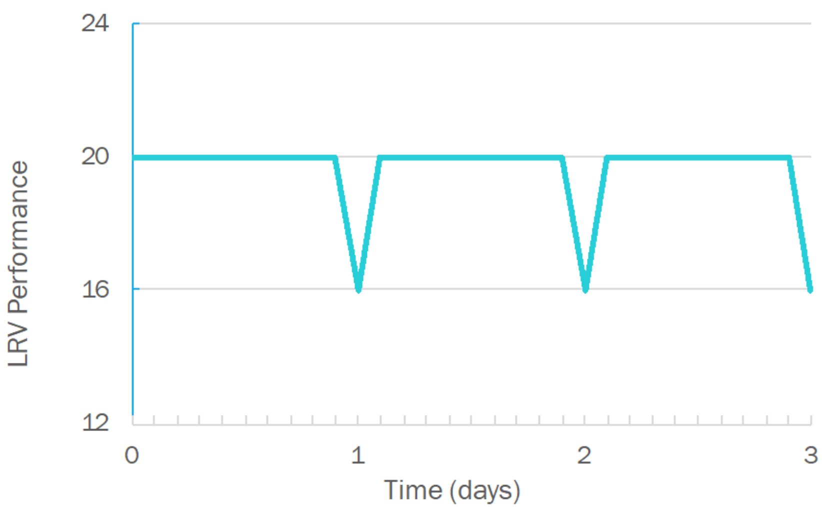
"To minimize the chance that the required log reductions necessary to meet the health objective are not consistently met, DPR projects must provide log reduction capacity in excess of the basic LRVs (redundant LRV treatment)."



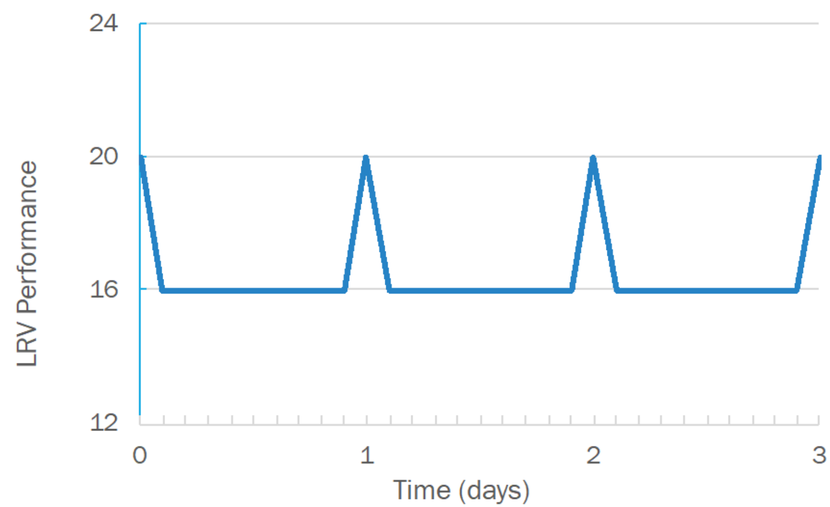


There is a direct link between treatment and risk

Draft regulations are vague on compliance



It is acceptable to drop to 16 once every 24 h:
(20 LRV 90% of the time
16 LRV 10% of the time)

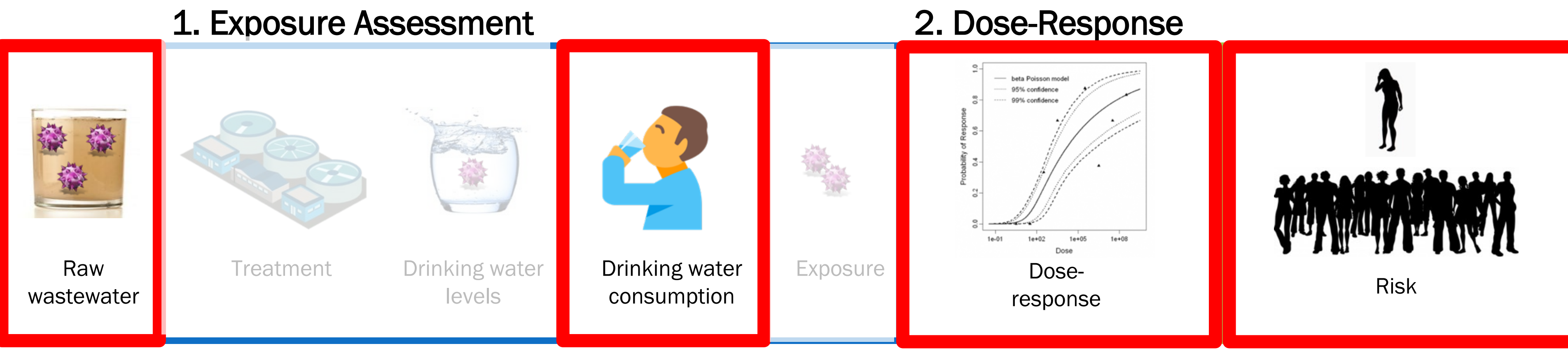


It is acceptable to go up to 20 once every 24 h:
(20 LRV 10% of the time
16 LRV 90% of the time)

How should compliance be specified?

Virus

Calculating the Benchmark Treatment – Virus



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

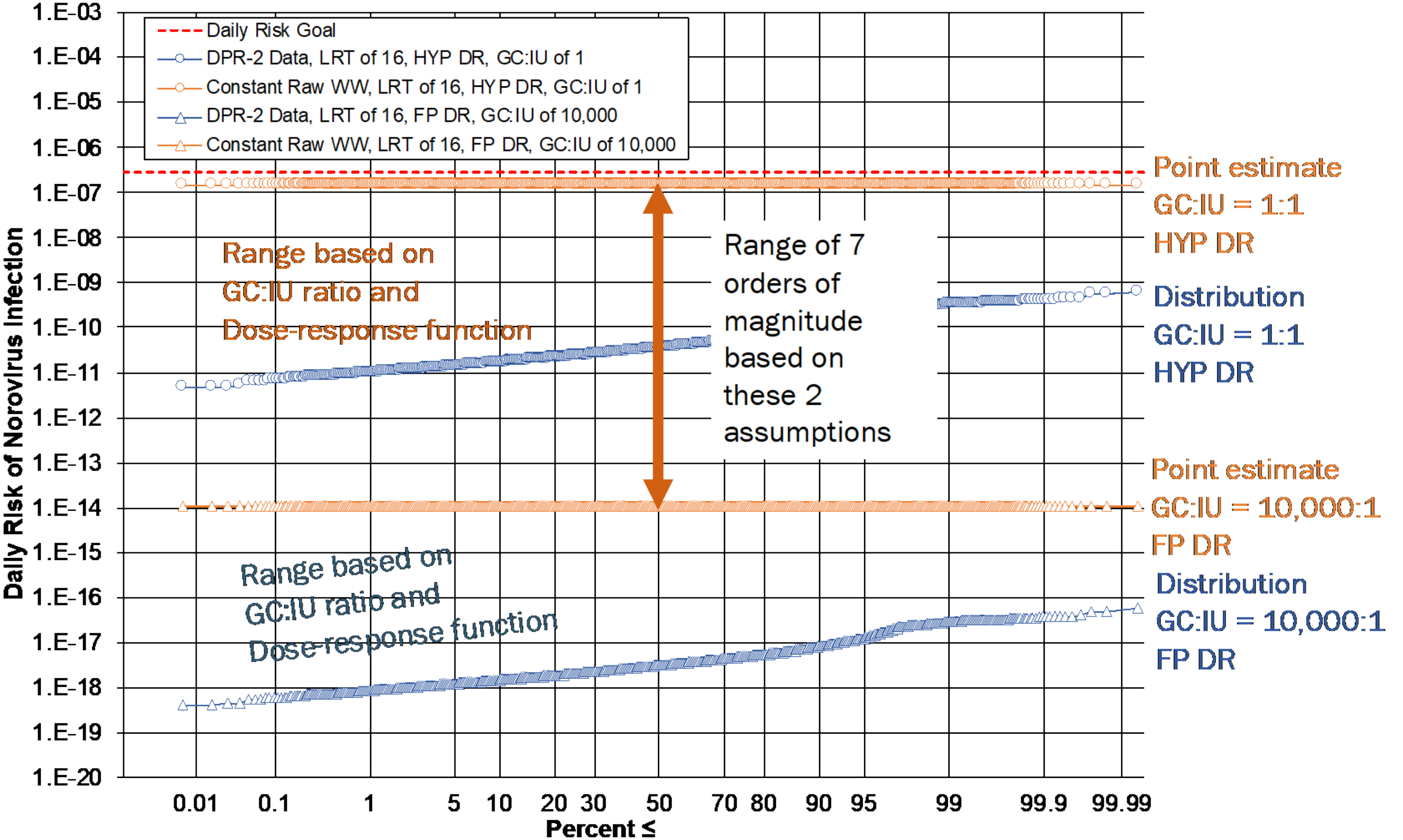
DDW assumed consumption of 2 L/day

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

Daily risk of 2.7×10^{-7}

Dose-response comparison

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



Recommendations from 1/13/22 Panel Workgroup Meeting & Updated based on 1/23/22 Subgroup Meeting

Recommendation:

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

Continue to Evaluate:

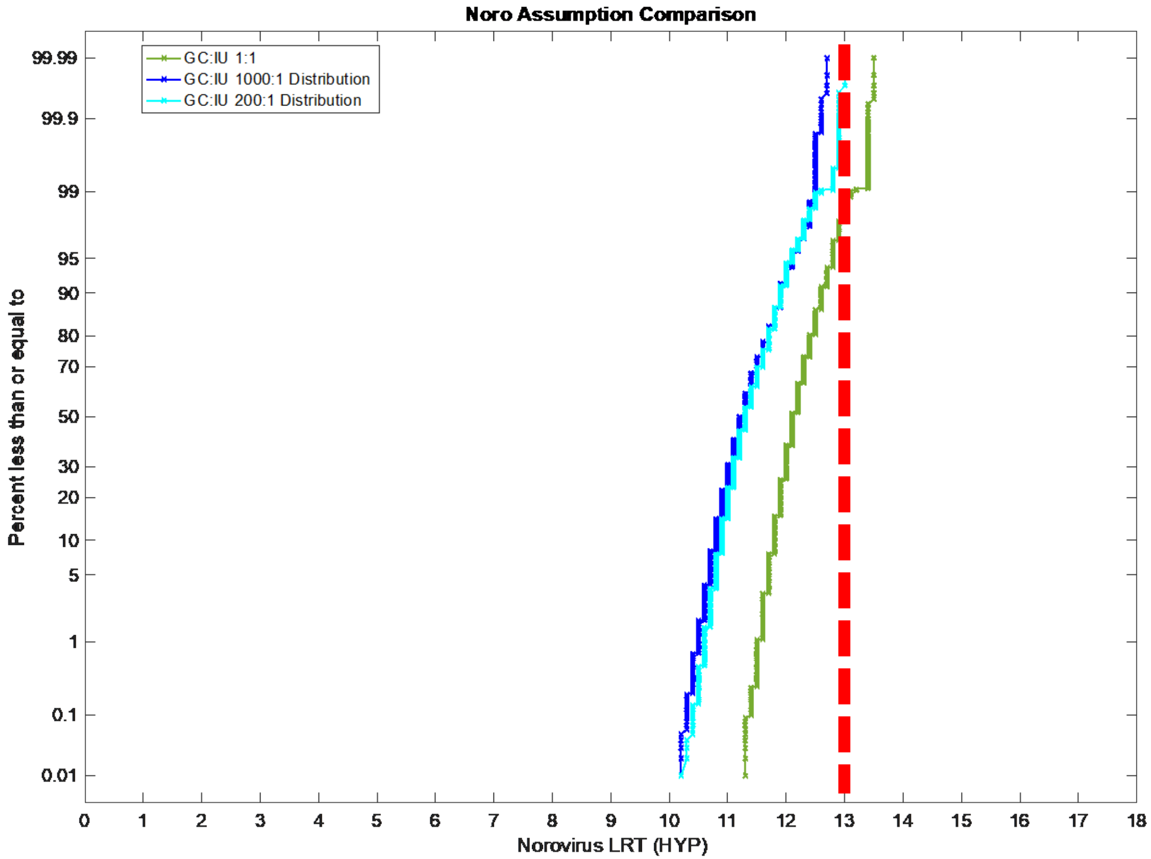
- **Type of data**: molecular and culture data
- **GC:IU ratios**: point estimates and ranges
- **Dose-response**: consider multiple functions

Norovirus – Range of Assumptions

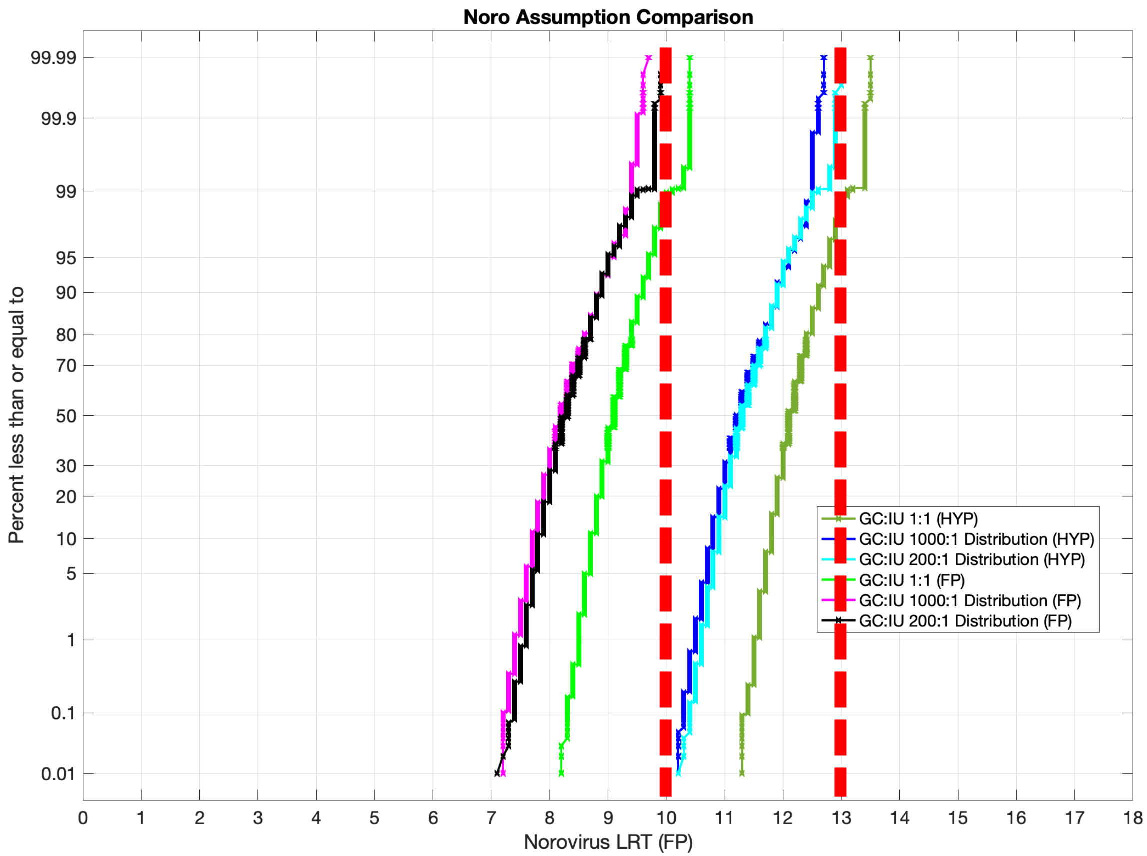
- Raw WW:
  - DPR-2 Distribution: μ_{log} = 4.0; σ_{log} = 1.2
- GC:IU
  - Option 1 = GC:IU of 1:1[1]
  - Option 2 = Uniform distribution of GC:IU of 200:1 to 1:1[2]
  - Option 3 = Uniform distribution of GC:IU of 1,000:1 to 1:1[3]
- Dose-Response
  - Hypergeometric (conservative)
  - Fractional-Poisson

[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) – Converge at 13



Norovirus Required LRVs (impact of HYP D-R and FP D-R)



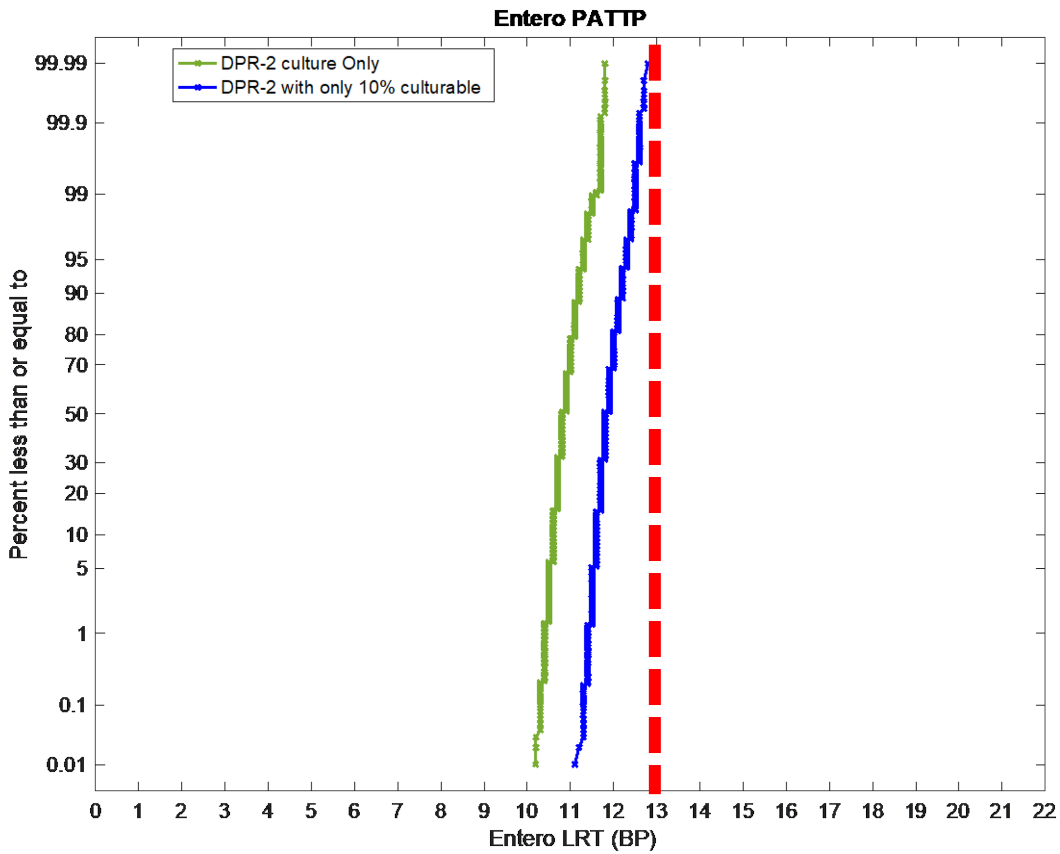
Range of potential virus LRVs based on Norovirus: 10 to 13

Enterovirus Assumptions

- Raw WW:
  - DPR-2 Distribution[1]: μ_{log} = 3.2; σ_{log} = 1.0
  - Assume 10% of total viruses were culturable[2]: μ_{log} = <u>4.2</u>; σ_{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 LRVs

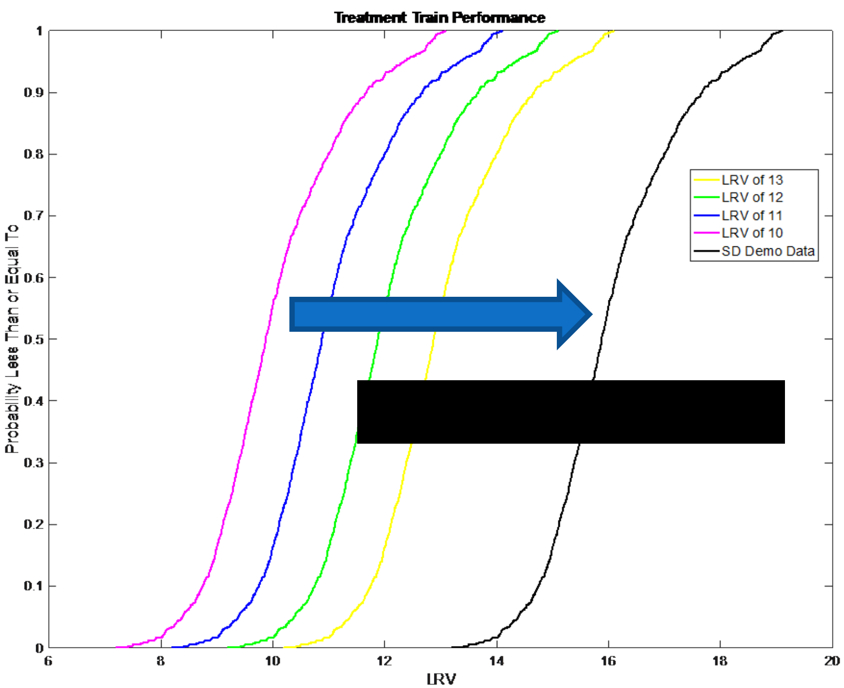


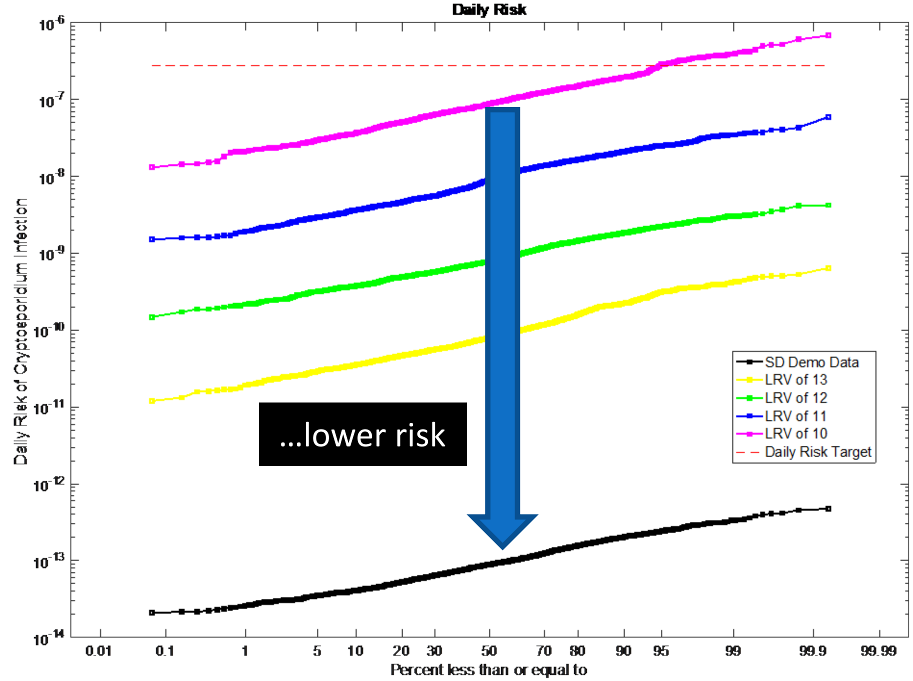
Upper-end of both enterovirus/rotavirus (culture) and norovirus (molecular) is 13 LRV

Failures

Redundancy and Risk

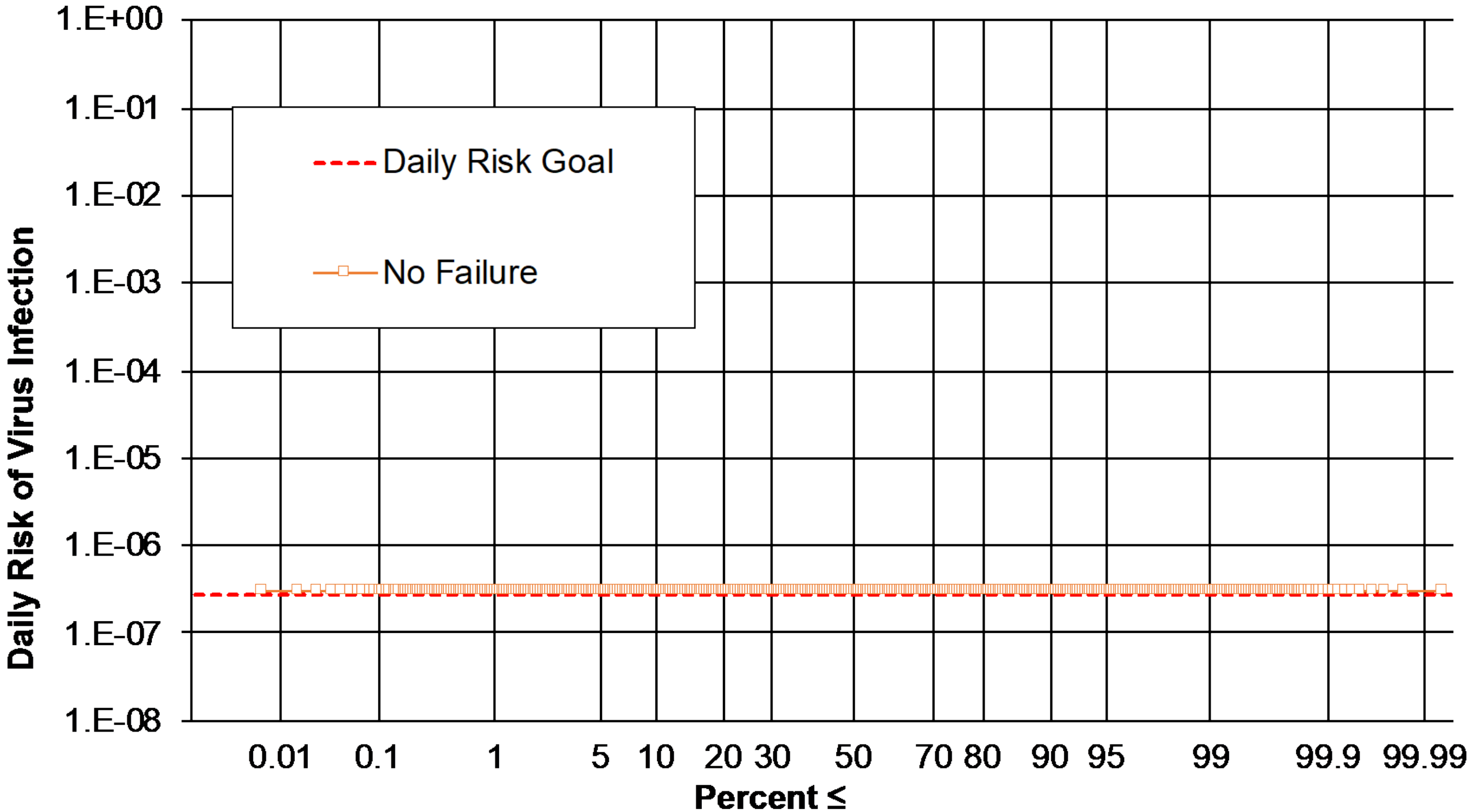
"To minimize the chance that the required log reductions necessary to meet the health objective are not consistently met, DPR projects must provide log reduction capacity in excess of the basic LRVs (redundant LRV treatment)."





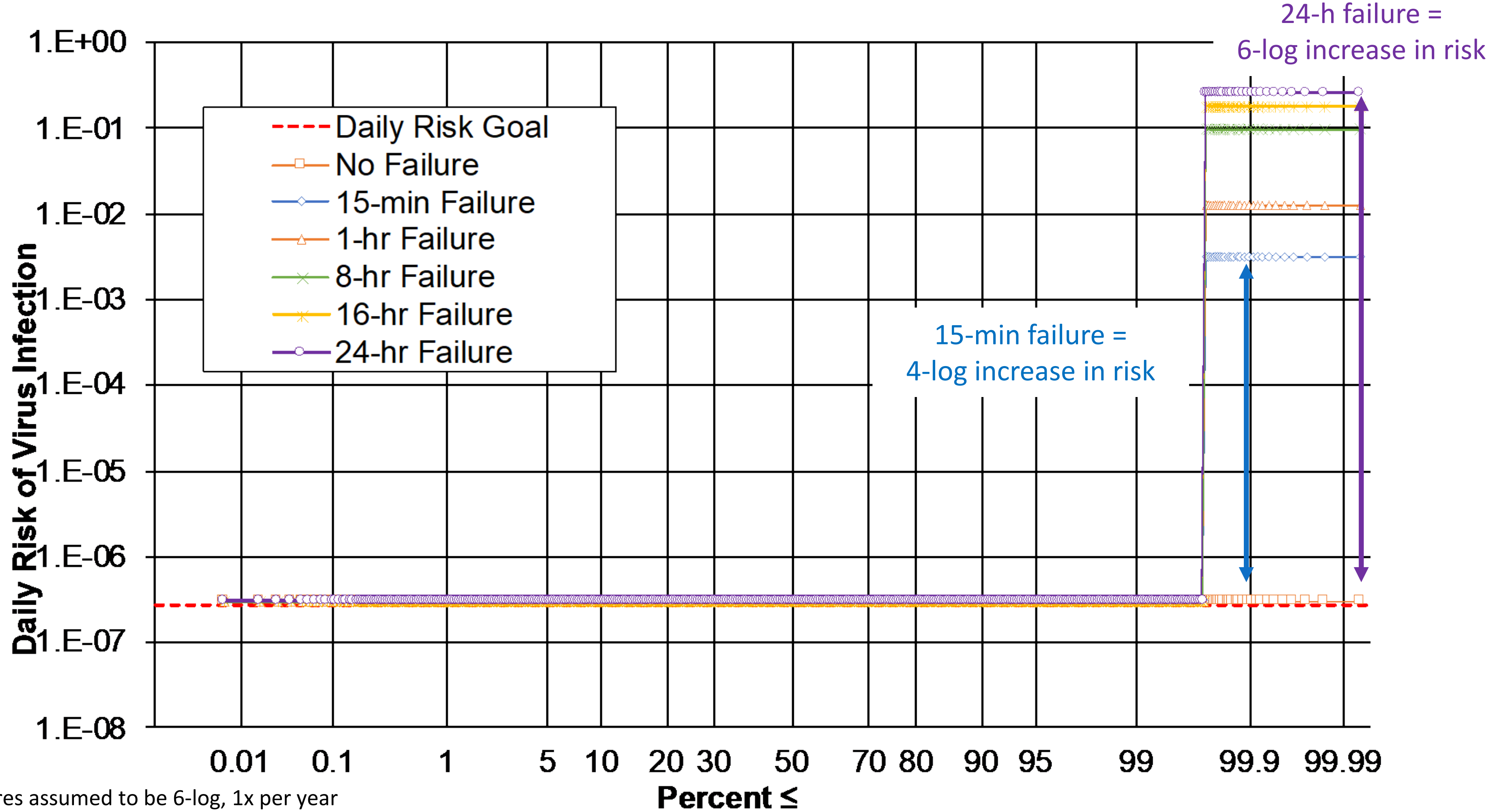
What is the appropriate level of redundancy?

Failure increases risk from 4- to 6-logs



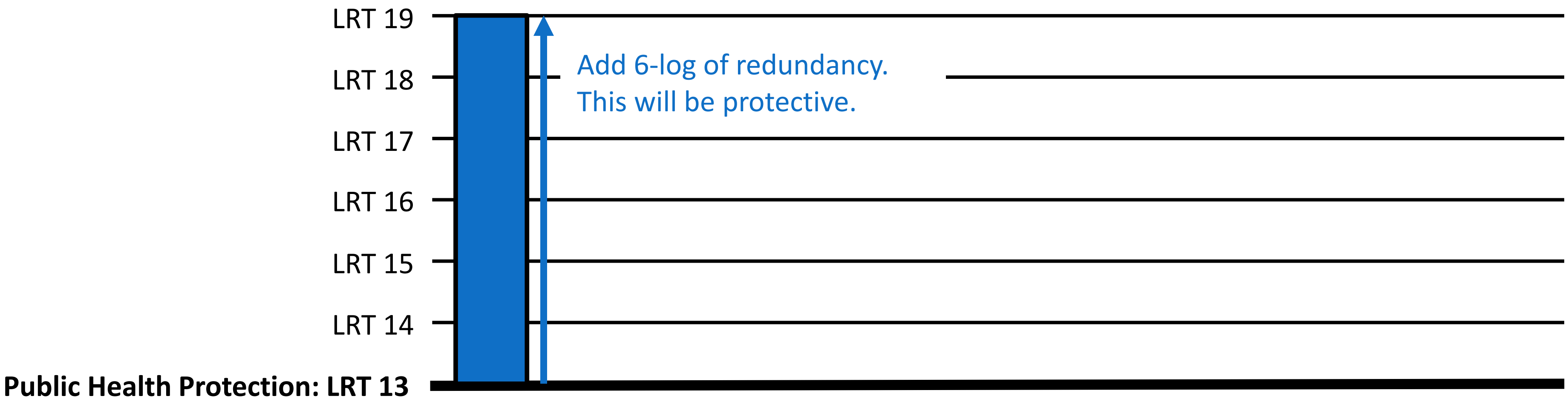
Failures assumed to be 6-log, 1x per year

Failure increases risk from 4- to 6-logs

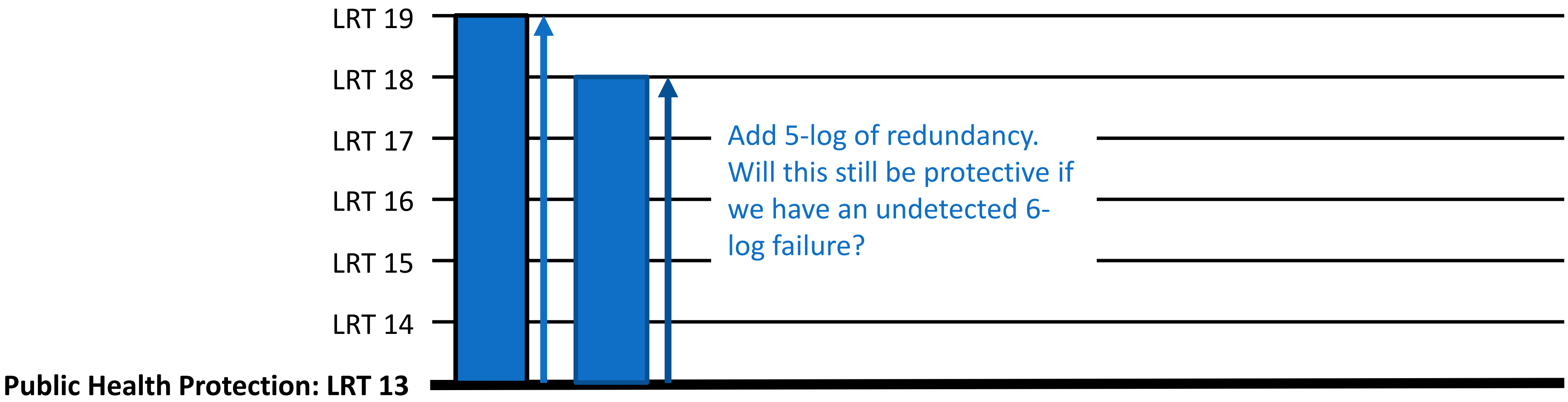


Failures assumed to be 6-log, 1x per year

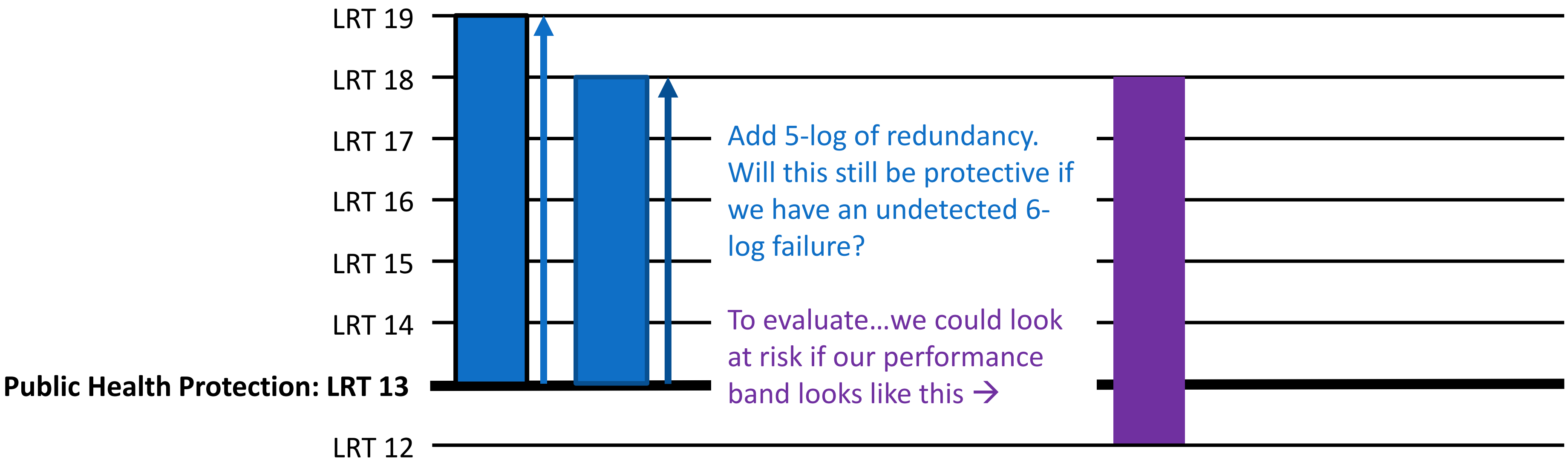
Approach for Evaluating Redundancy



Approach for Evaluating Redundancy



Approach for Evaluating Redundancy

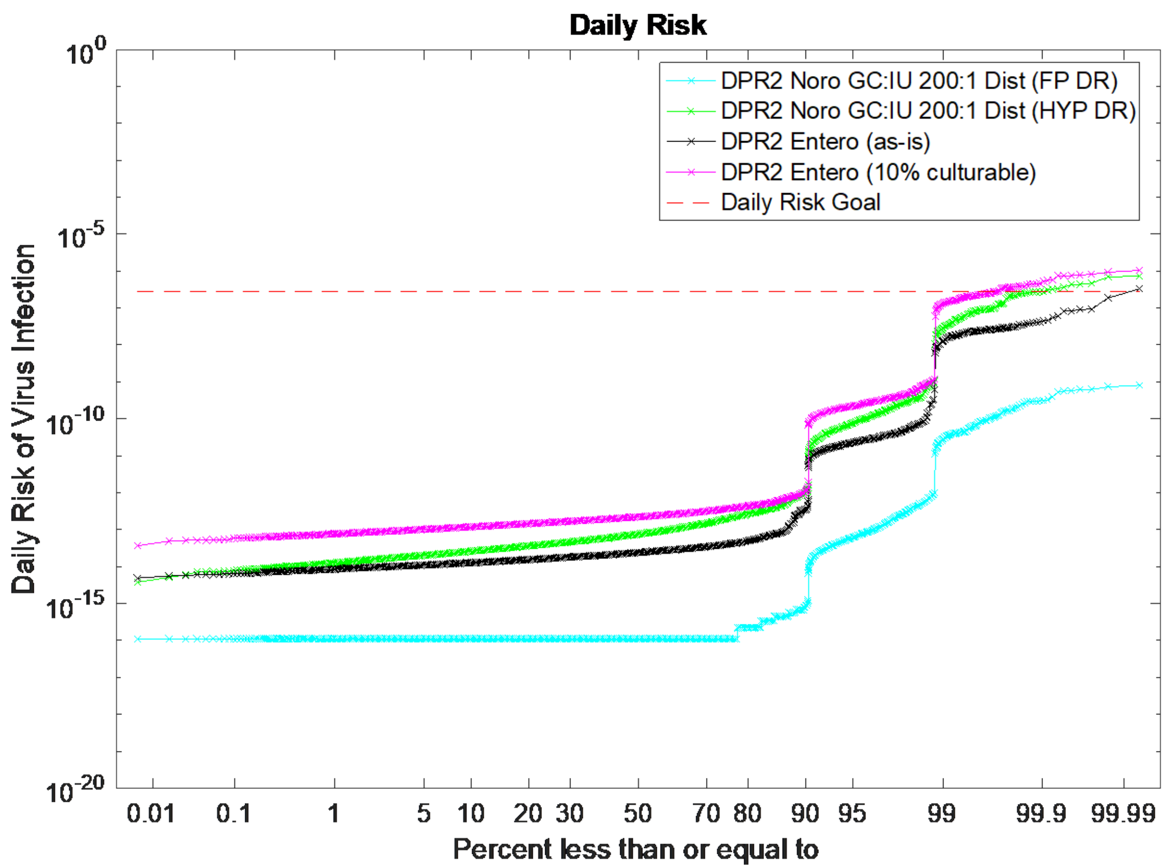


Evaluating Risk – Performance Assumption

- Treatment goals: 13 LRT + 5 LRT redundancy = 18
- Model includes **undetected** complete and intermediate failure 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

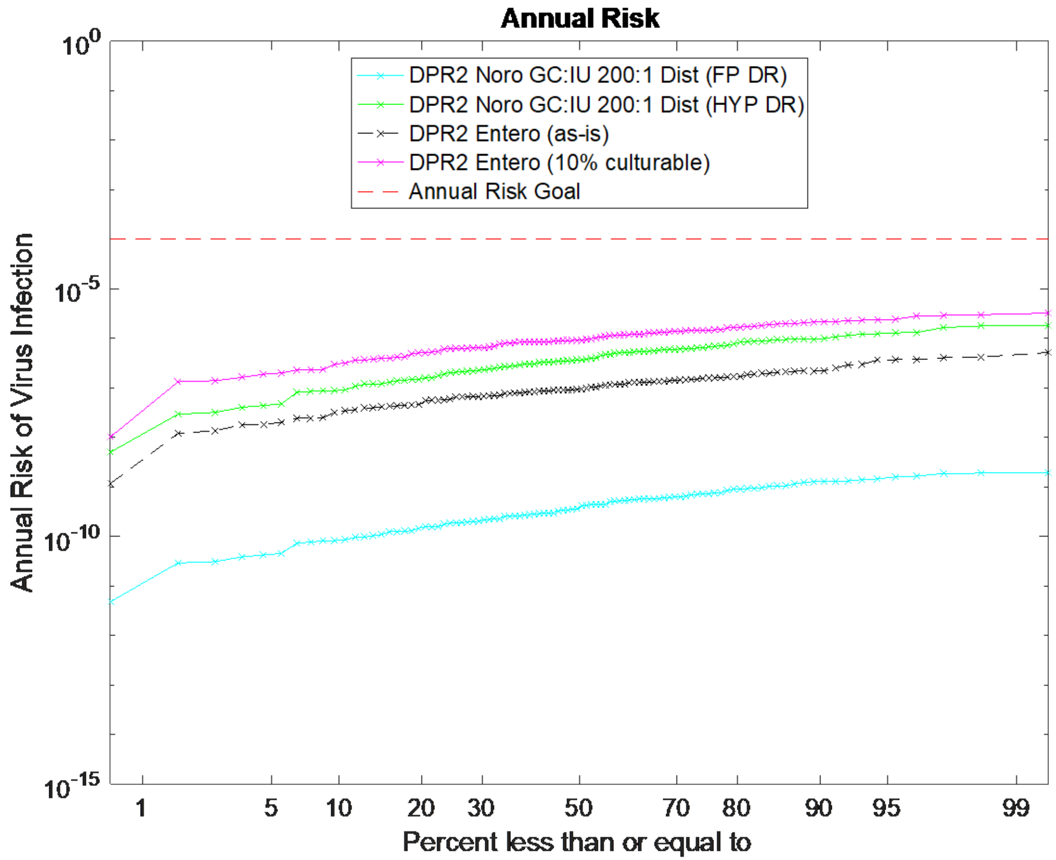
12 LRV – 1%
15 LRV – 9%
18 LRV – 90%



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

Virus Comparison – Annual Risk

12 LRV– 1%
15 LRV – 9%
18 LRV – 90%



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

Potential Virus Requirements

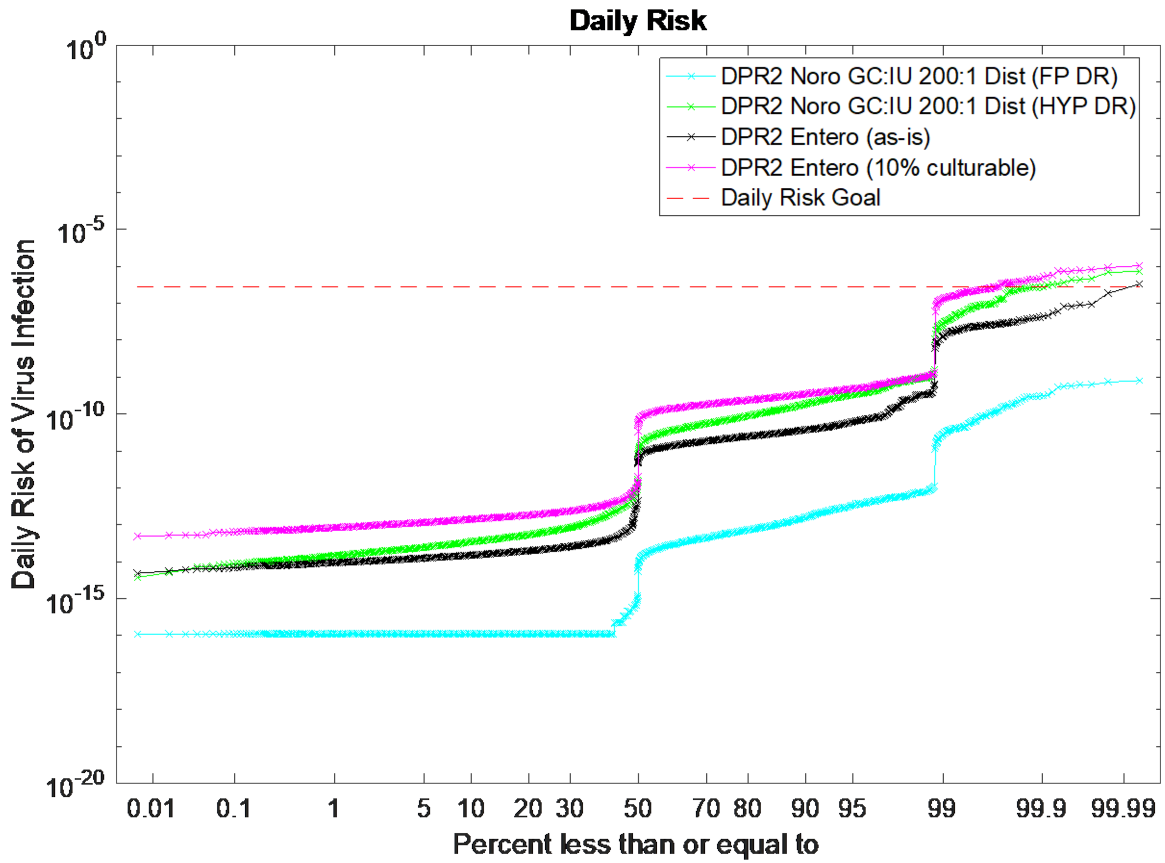
- Minimum treatment for public health protection: LRT = 13
- Minimum redundancy needed to address undetected failures: +5 logs
  - 5-log buffer protective against a conservative 6-log failure rate (1% occurrence)
  - 99% compliance with daily risk goal
  - >99% with annual risk goal (< once in 100 years)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

Evaluating Risk – Performance Assumption

- Treatment goals: 13 LRT + 5 LRT redundancy = 18
- Model includes **undetected** complete and intermediate failure scenarios
  - 18 LRT – 50% -- performance typically at design conditions (13 + 5)
  - 15 LRT – 49% -- 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 – 49%
18 LRT – 50%

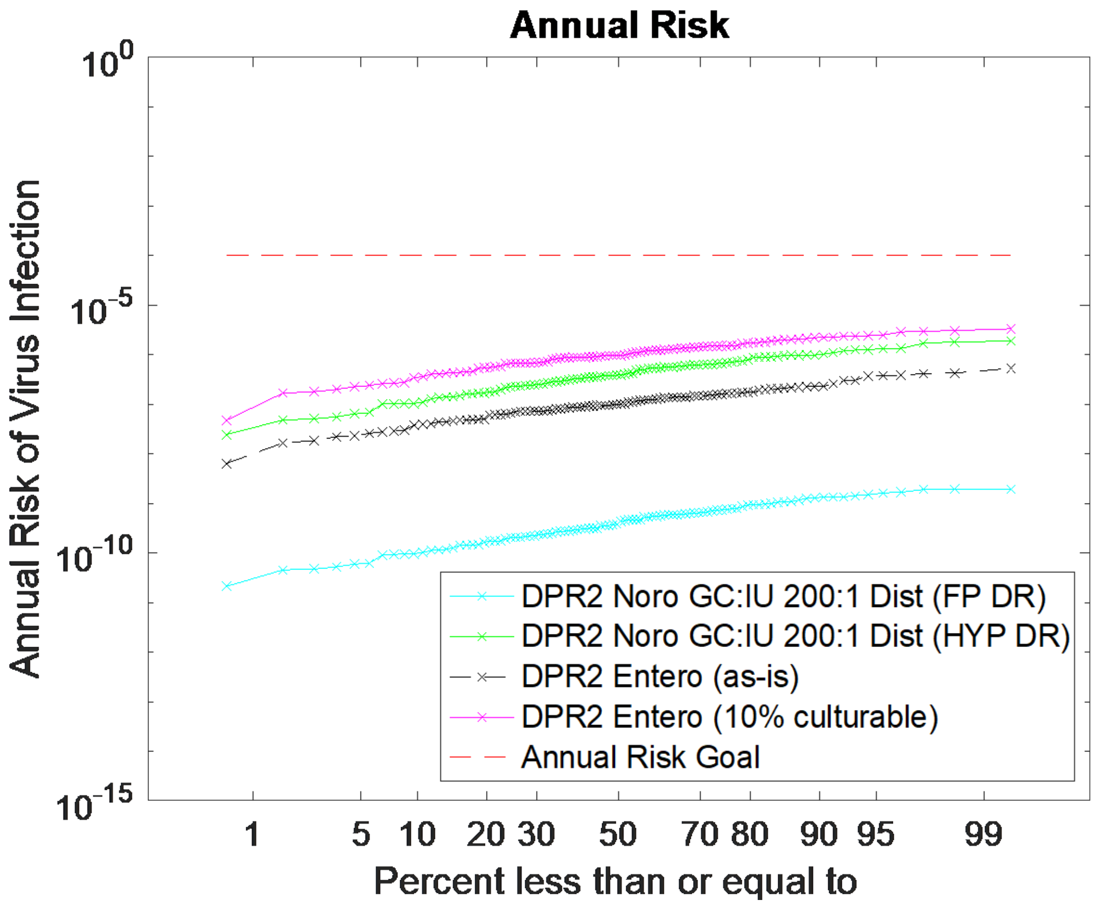


Entero – 10% culturable
NoV – hypergeometric
Entero – no adjustment

NoV – fractional Poisson

Virus Comparison – Annual Risk

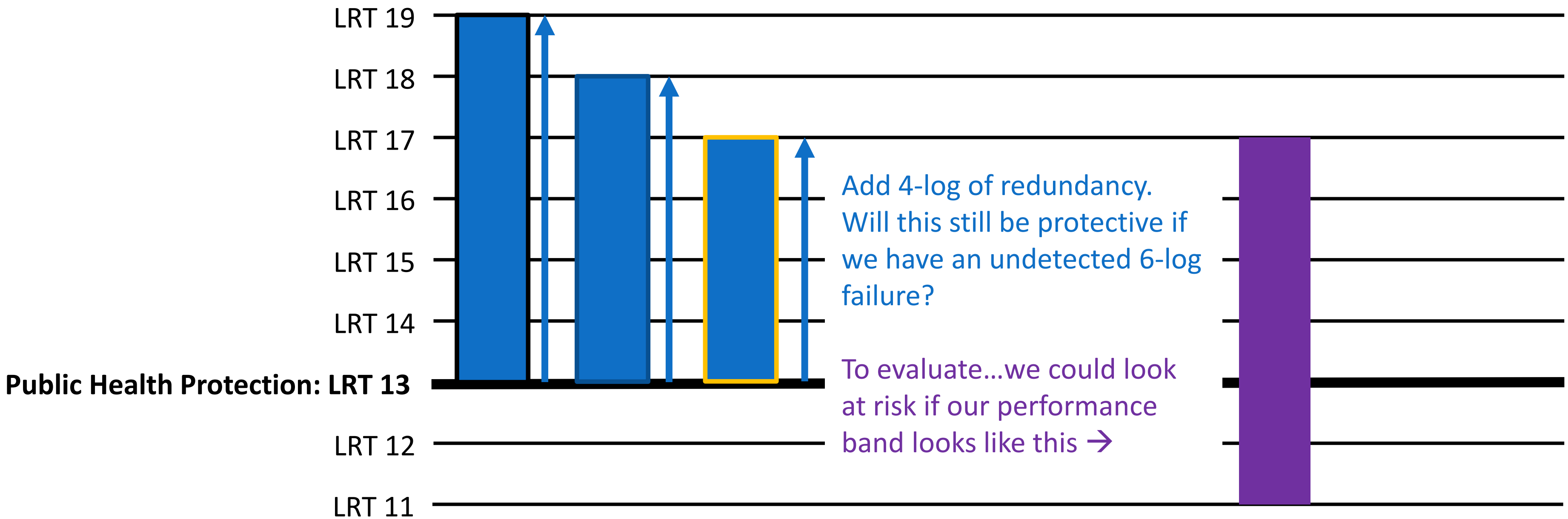
12 LRT – 1%
15 LRT – 49%
18 LRT – 50%



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

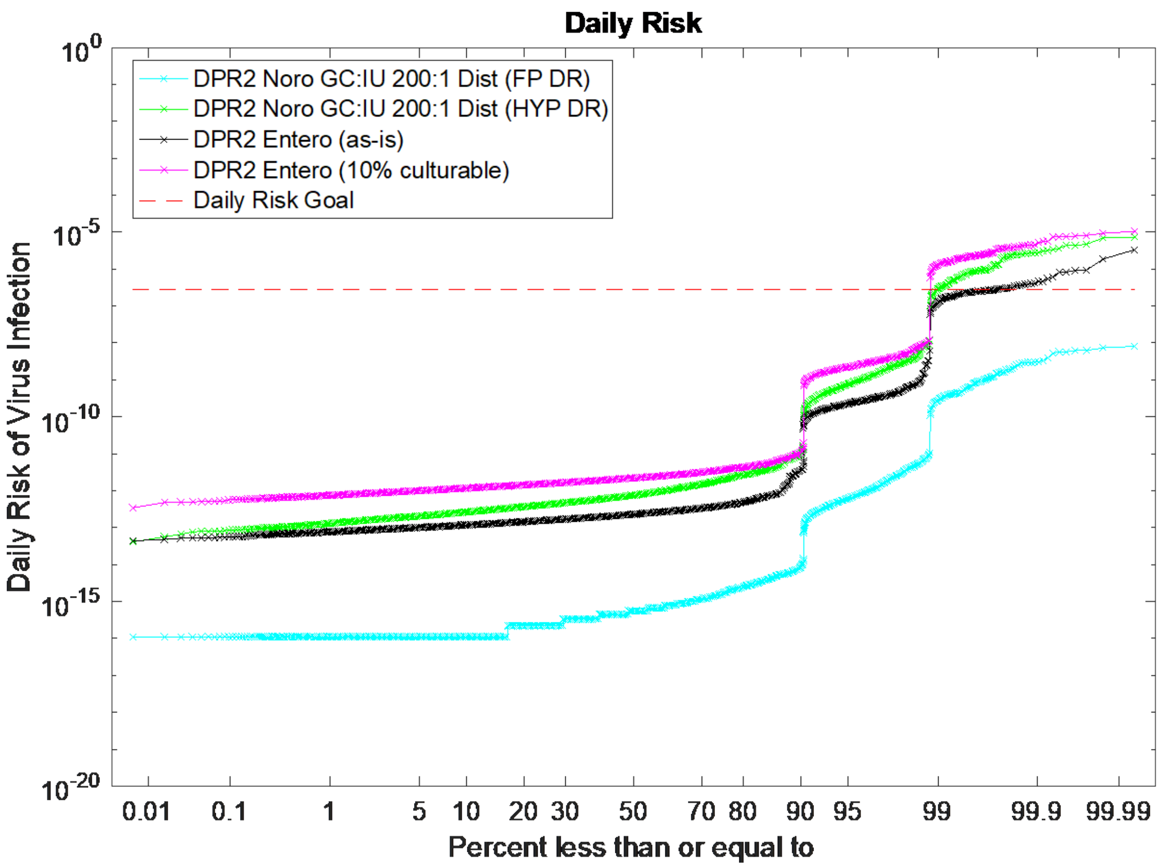
NoV – fractional Poisson

Would this be okay with less redundancy?



6-log failure with 4-log redundancy (daily risk)

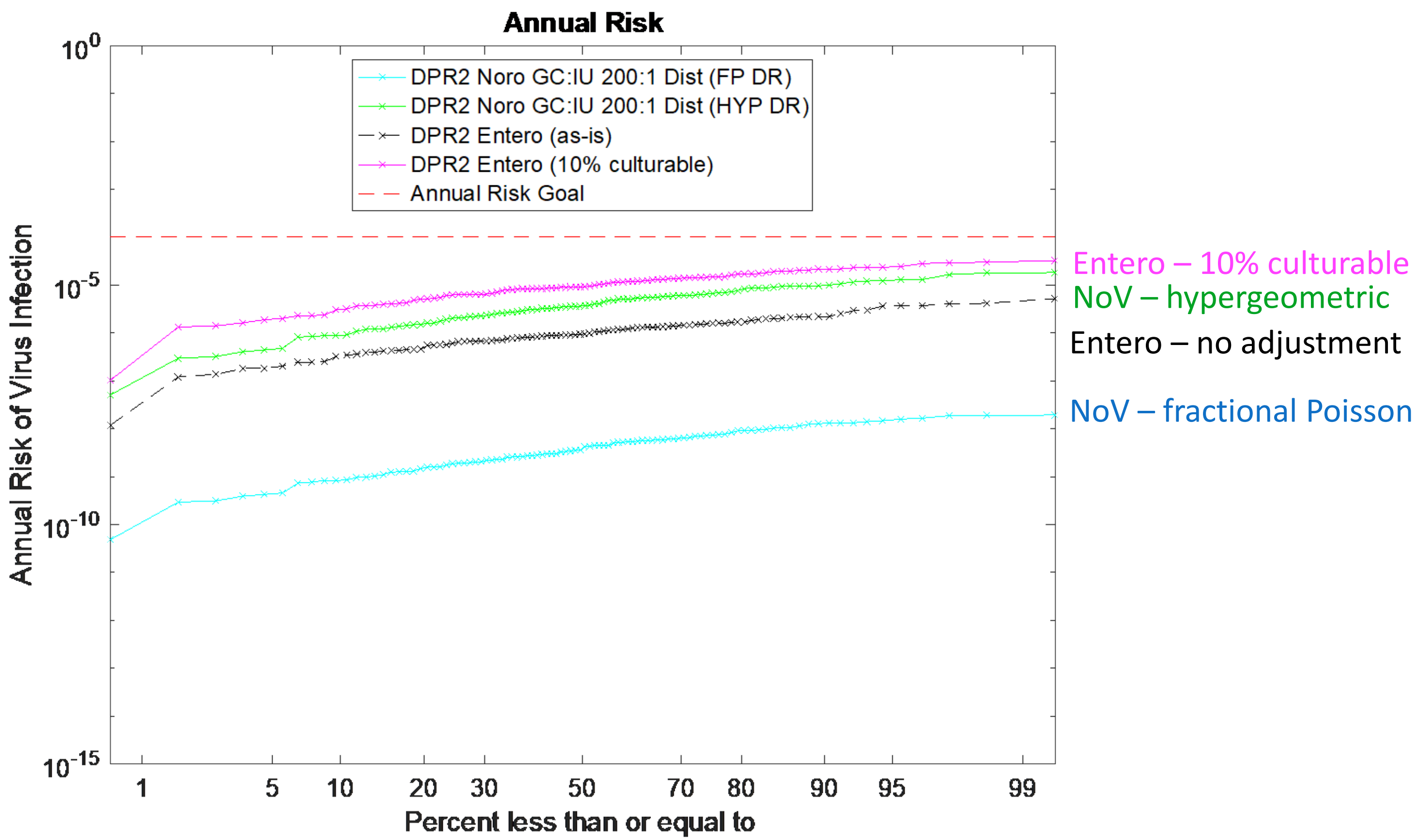
11 LRT – 1%
14 LRT – 9%
17 LRT – 90%



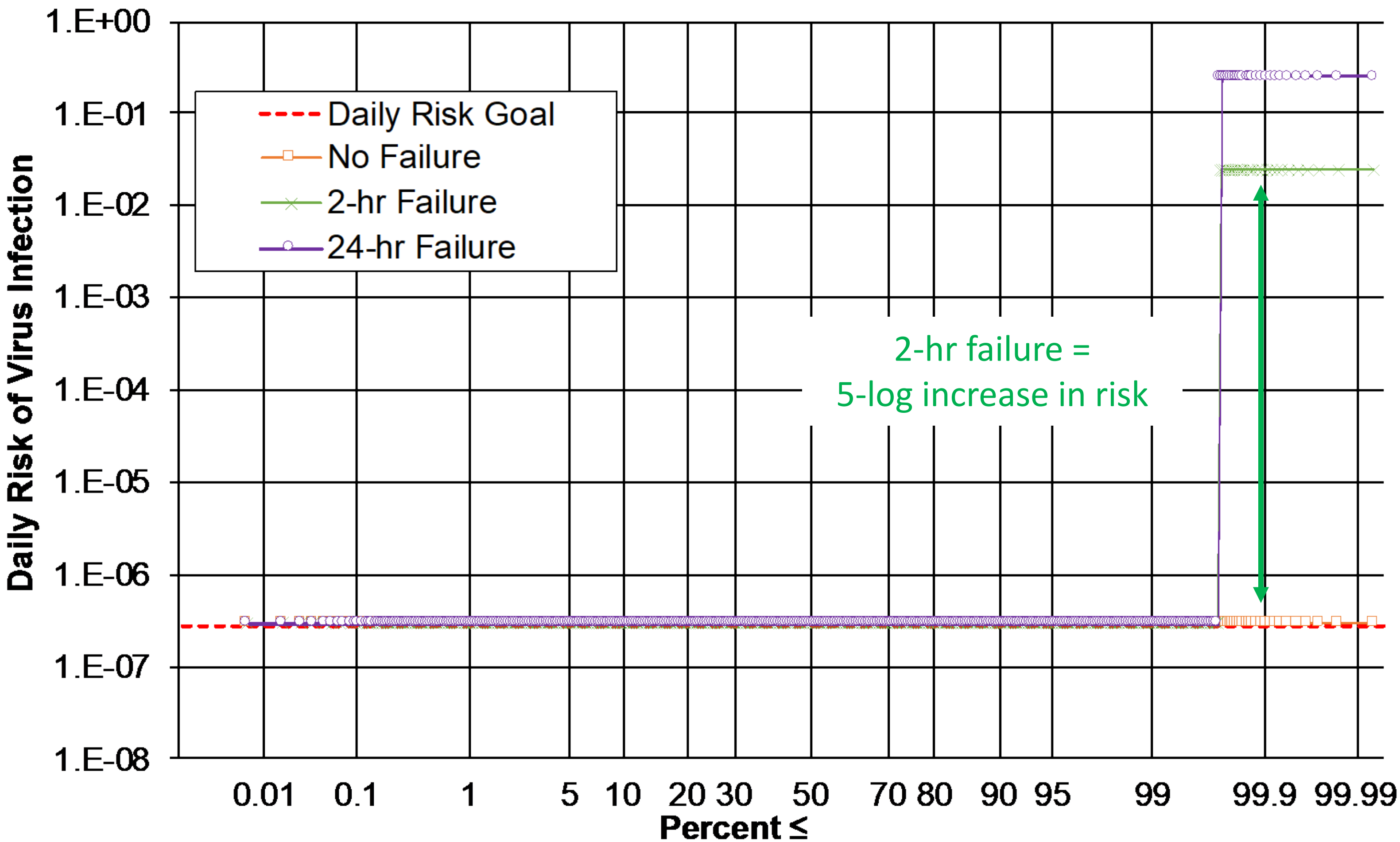
Entero – 10% culturable
NoV – hypergeometric
Entero – no adjustment
NoV – fractional Poisson

6-log failure with 4-log redundancy still complies with annual risk

11 LRT – 1%
14 LRT – 9%
17 LRT – 90%



What if we had different failure assumptions?



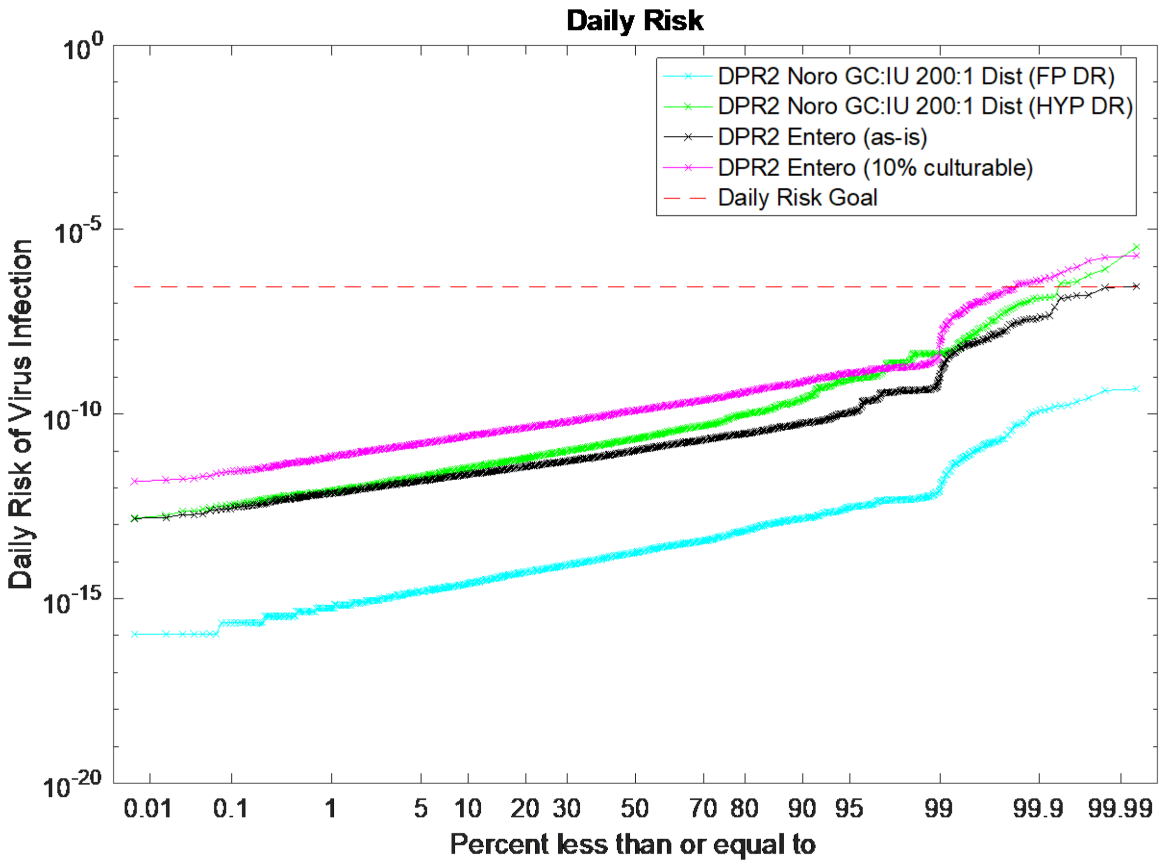
Different Failure Assumptions – Model Approach

- A **2-hr, 6-log failure** = 5-log increase in risk
- To protect against this, 5-log redundancy would be adequate.
- **Would 4-log redundancy protect against this type of failure?**

- Treatment goals: 13 LRT + 4 LRT redundancy = 17
- Model includes **undetected** complete and intermediate 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 for 2-hrs on 1% of the days (17 – 6)

Virus Comparison – Daily Risk (2-hr failures)

11 LRT – 1%
14 LRT – 9%
17 LRT – 90%



NoV – hypergeometric
Entero – 10% culturable
Entero – no adjustment
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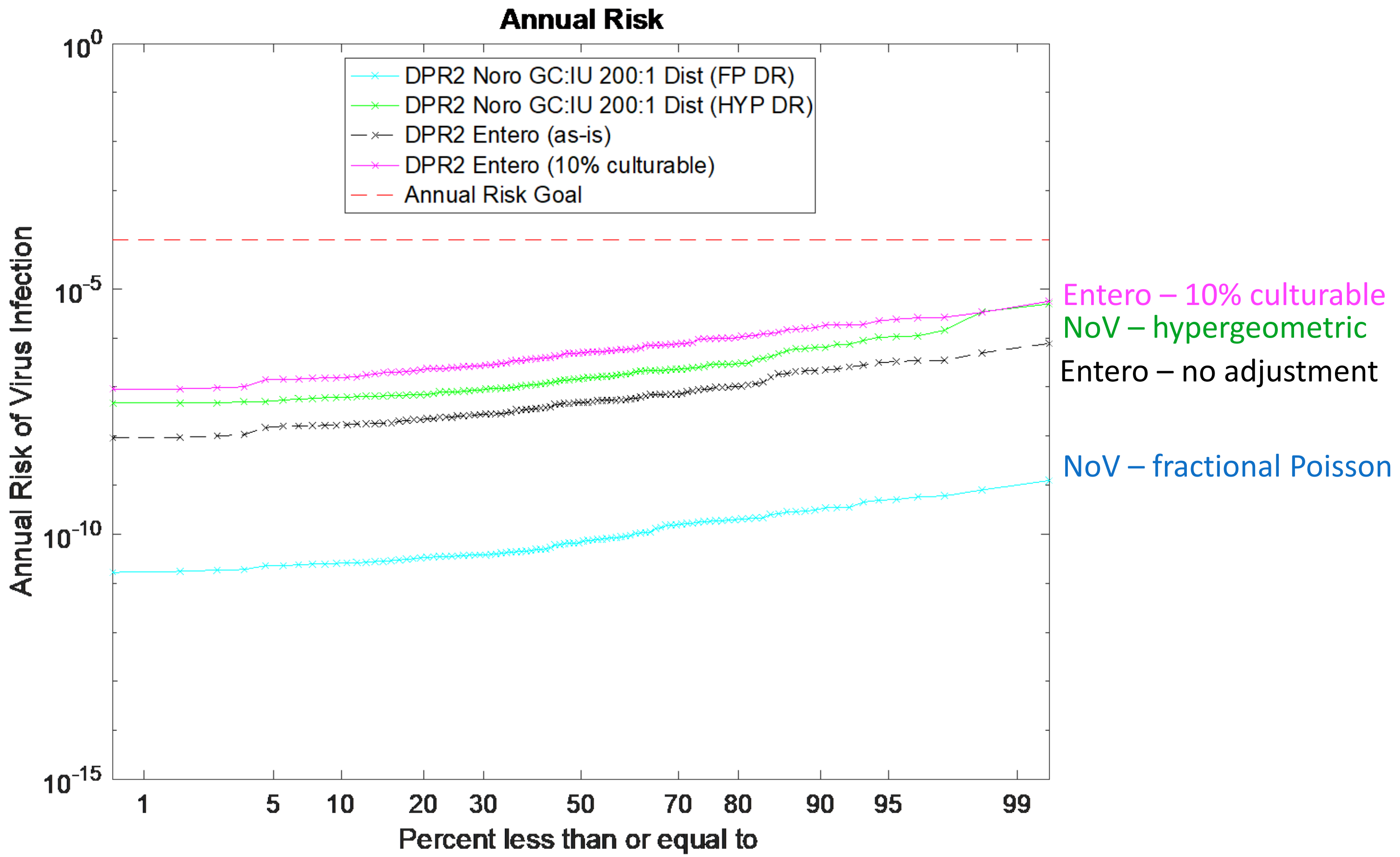
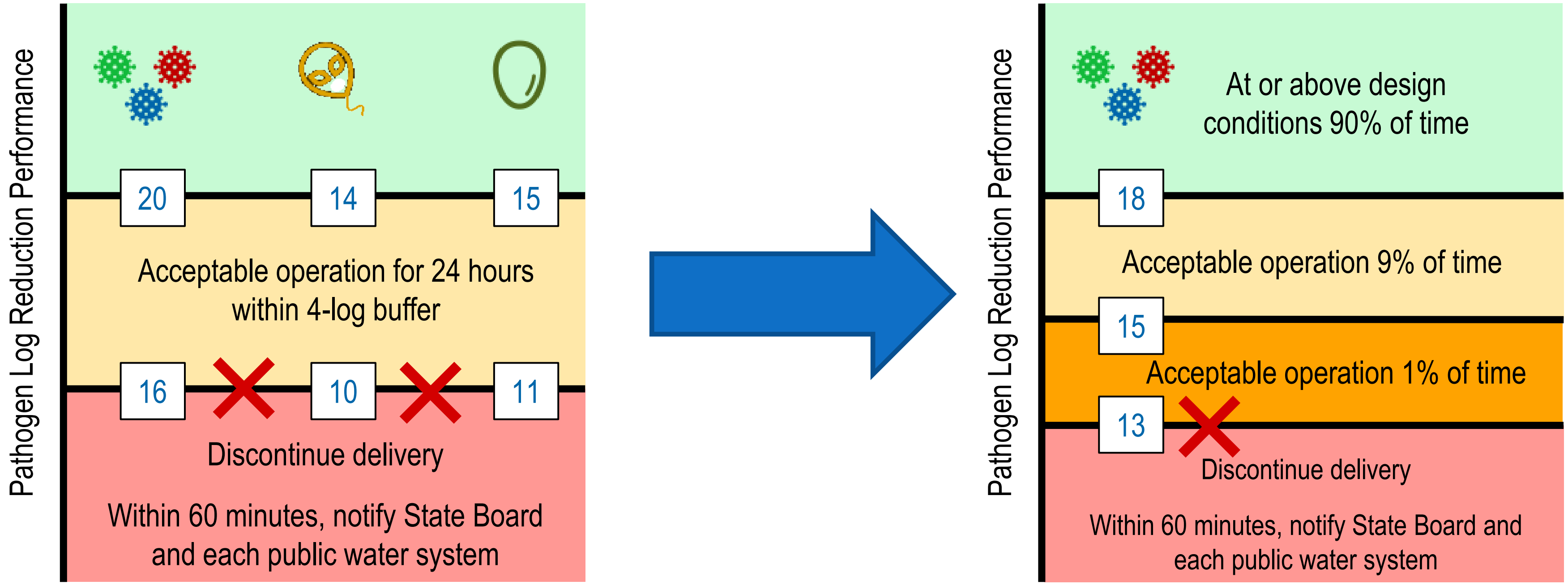
Virus Comparison – Annual Risk (2-hr failures)

11 LRT – 1%
14 LRT – 9%
17 LRT – 90%



What are the criteria? (5-log redundancy)

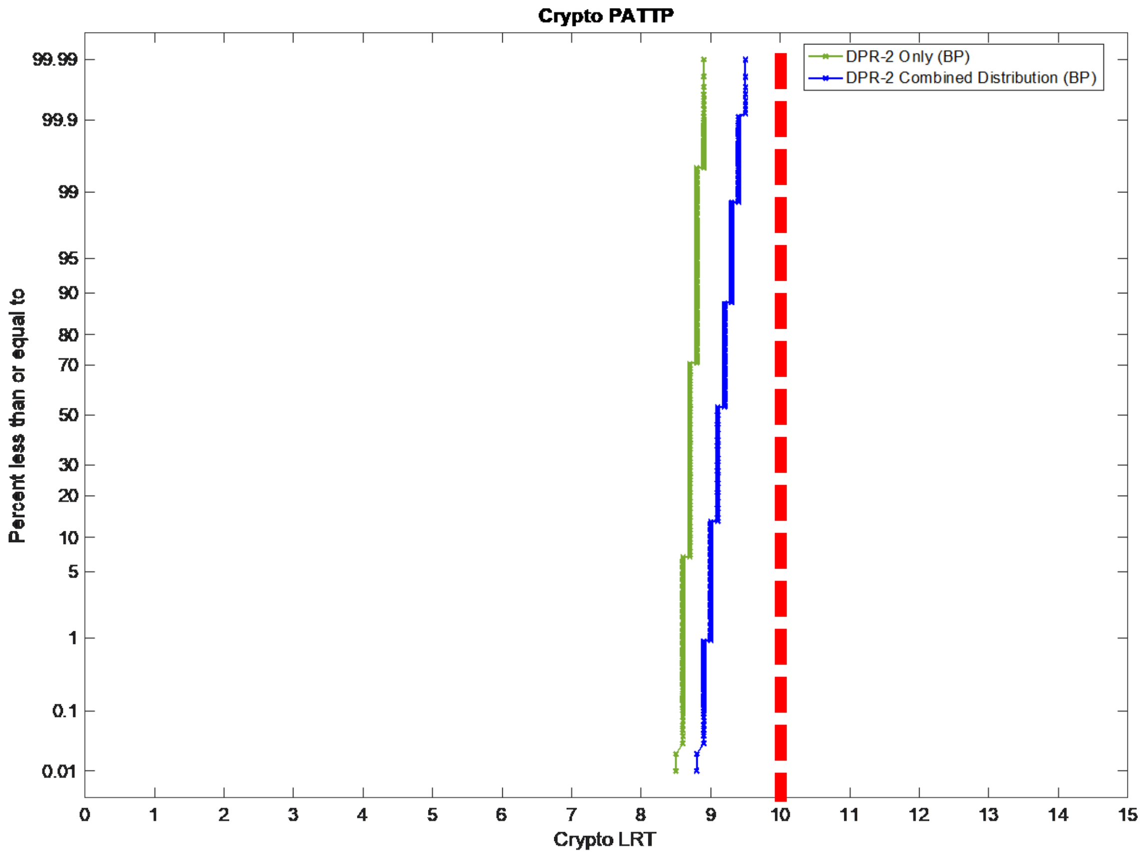


Crypto

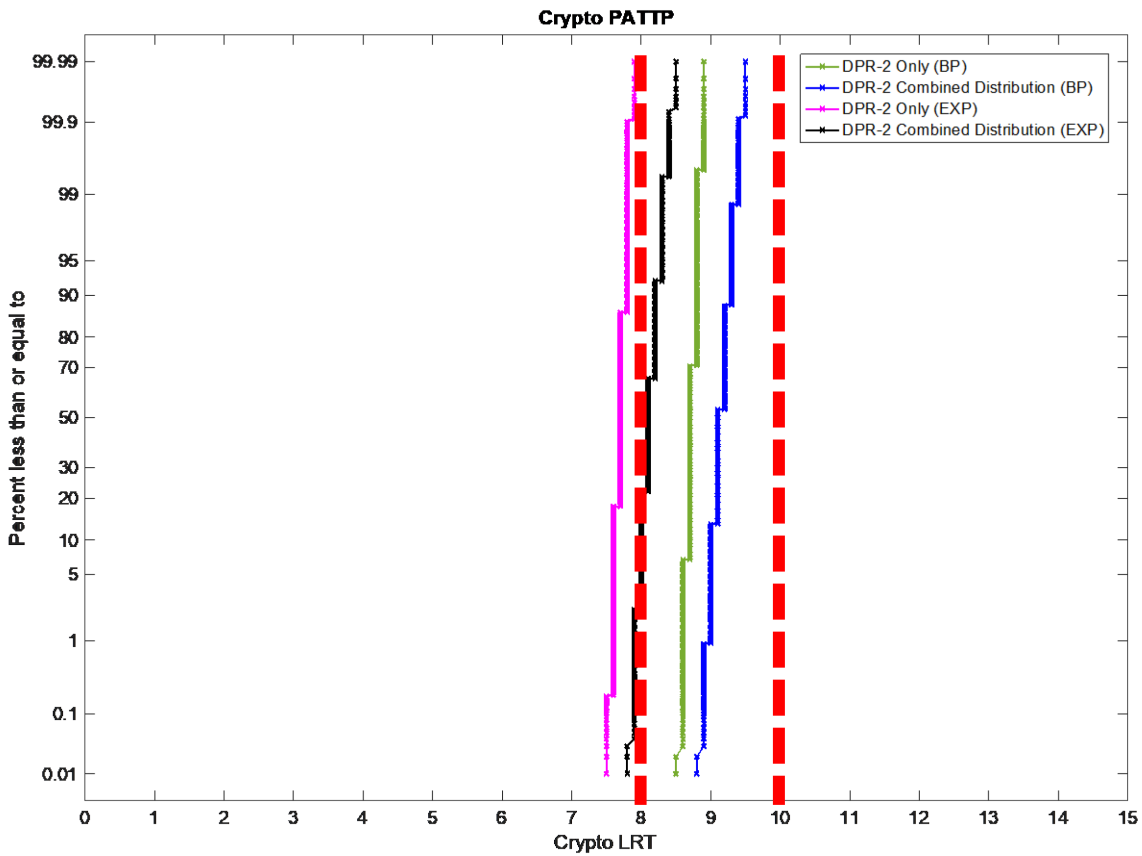
Crypto

- 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)



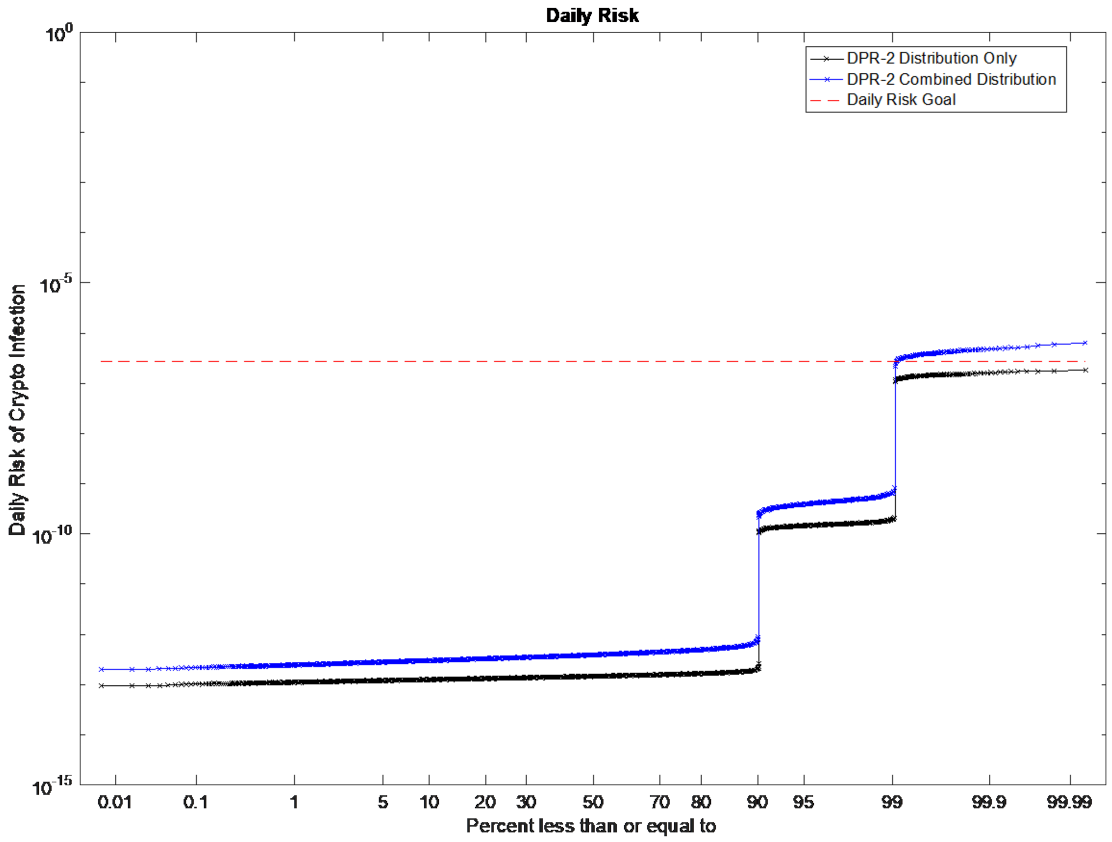
Crypto Required LRTs (Exponential D-R)



Range of potential Crypto LRTs: 8 to 10

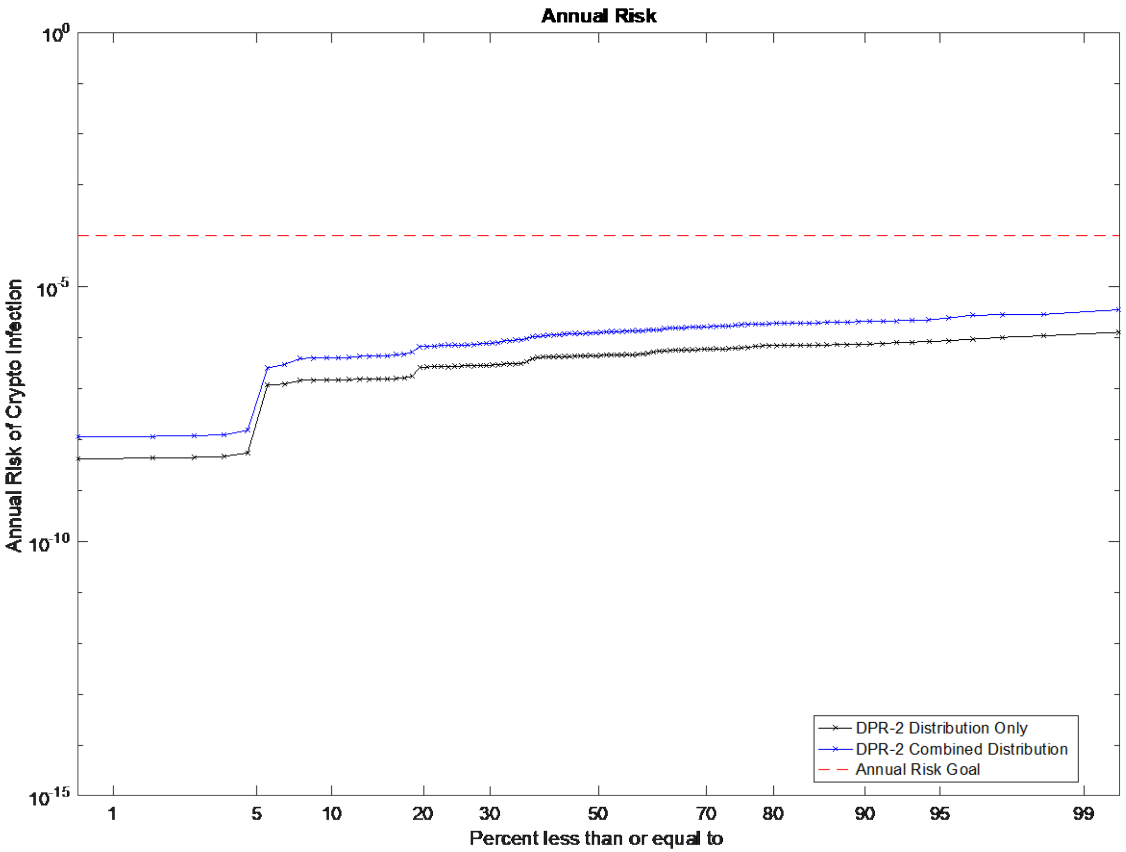
Crypto – Daily Risk with 5-log redundancy

9 LRT – 1%
12 LRT – 9%
15 LRT – 90%



Crypto – Annual Risk with 5-log redundancy

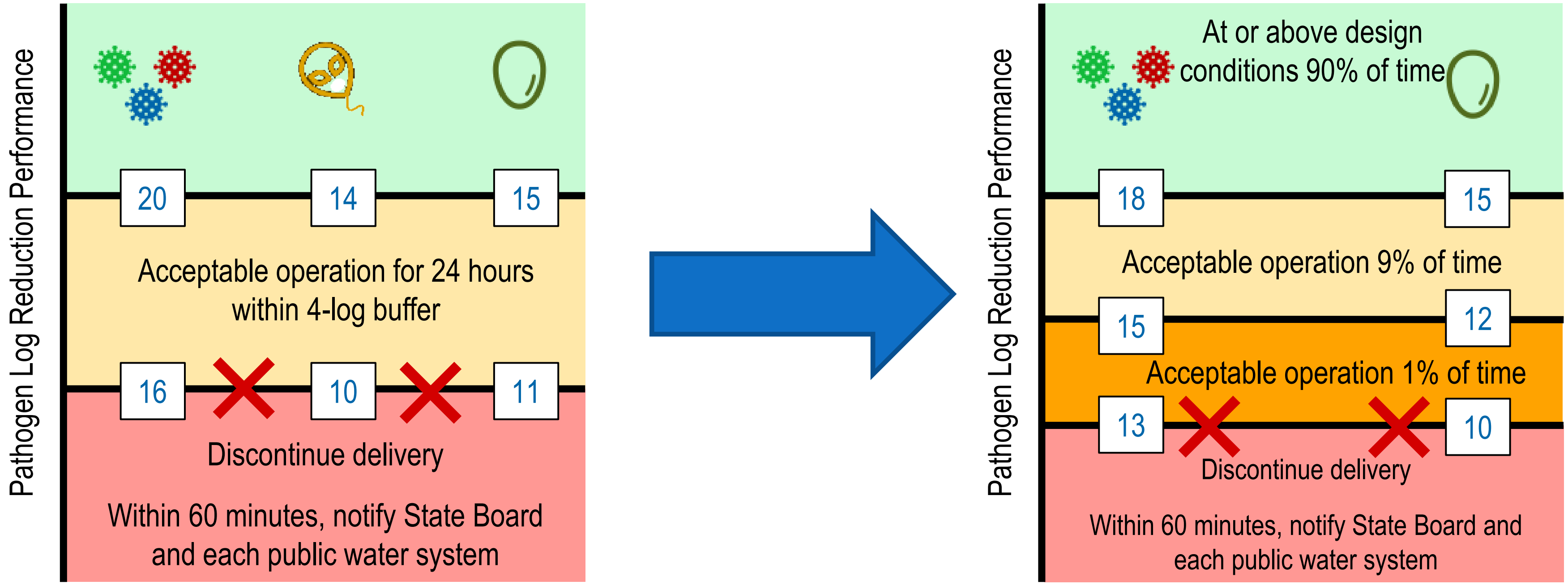
9 LRT – 1%
12 LRT – 9%
15 LRT – 90%



Potential Crypto Requirements

- Minimum treatment for public health protection: LRT = 10
- Minimum redundancy needed to address undetected 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)



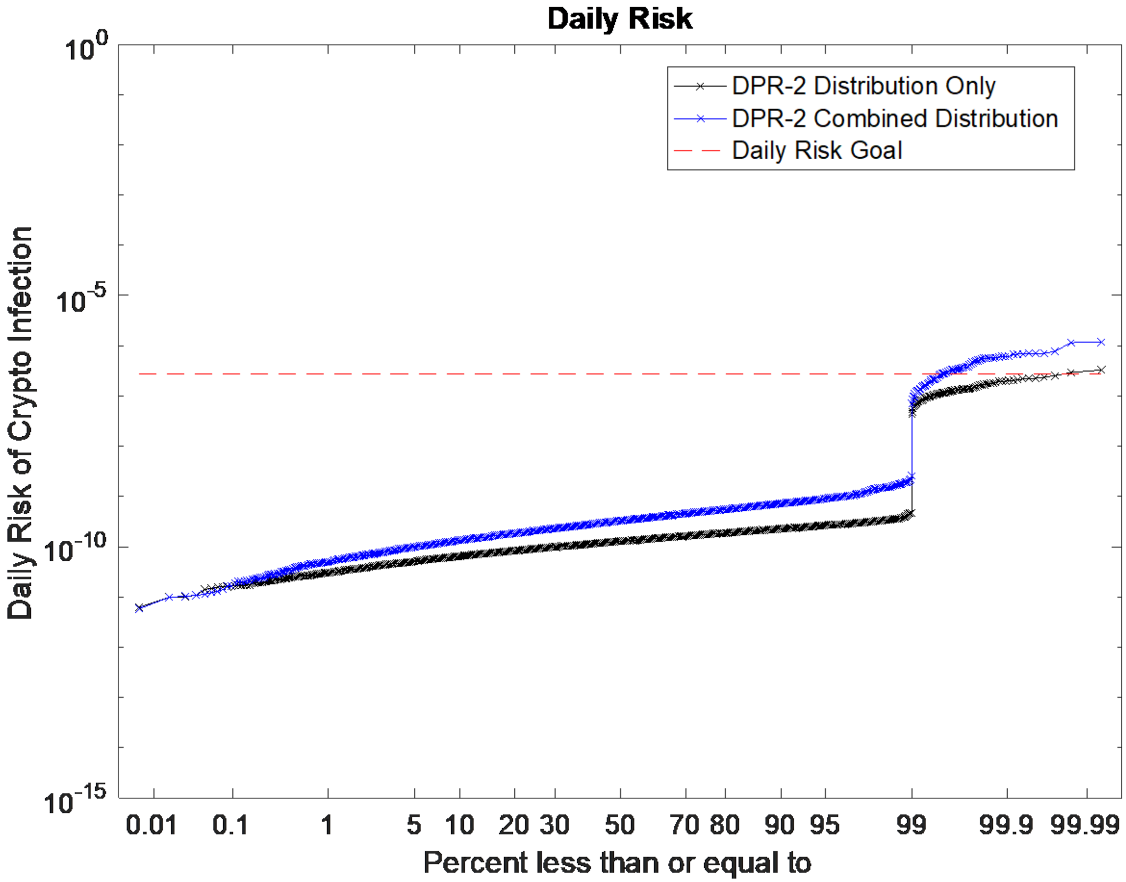
Different Failure Assumptions – Model Approach

- A **2-hr, 6-log failure** = 5-log increase in risk
- To protect against this, 5-log redundancy would be adequate.
- **Would 4-log redundancy protect against this type of failure?**

- Treatment goals: 10 LRT + 4 LRT redundancy = 14
- Model includes **undetected** complete and intermediate 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 for 2-hrs on 1% of the days (10 – 6)

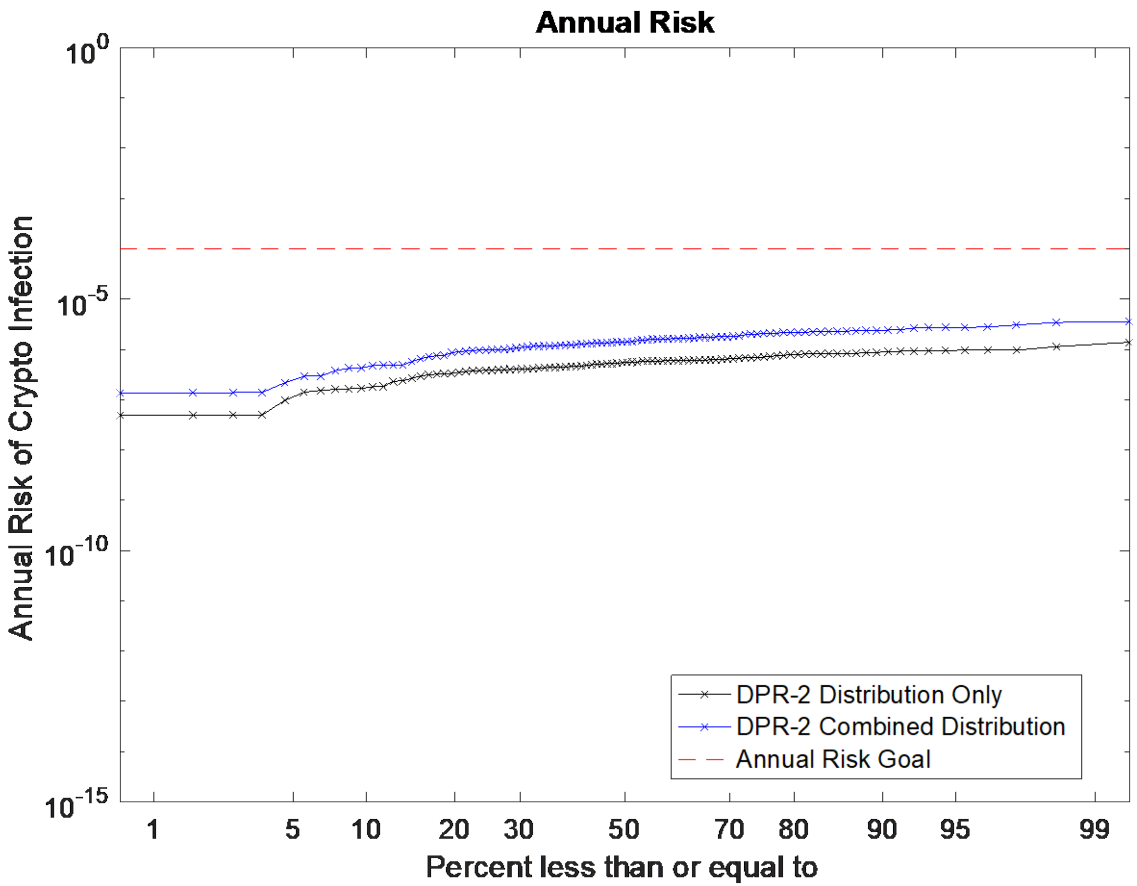
Crypto – Daily Risk with 4-log redundancy and 2-hr failures

8 LRT – 1%
11 LRT – 9%
14 LRT – 90%



Crypto – Annual Risk with 4-log redundancy and 2-hr failures

8 LRT – 1%
11 LRT – 9%
14 LRT – 90%

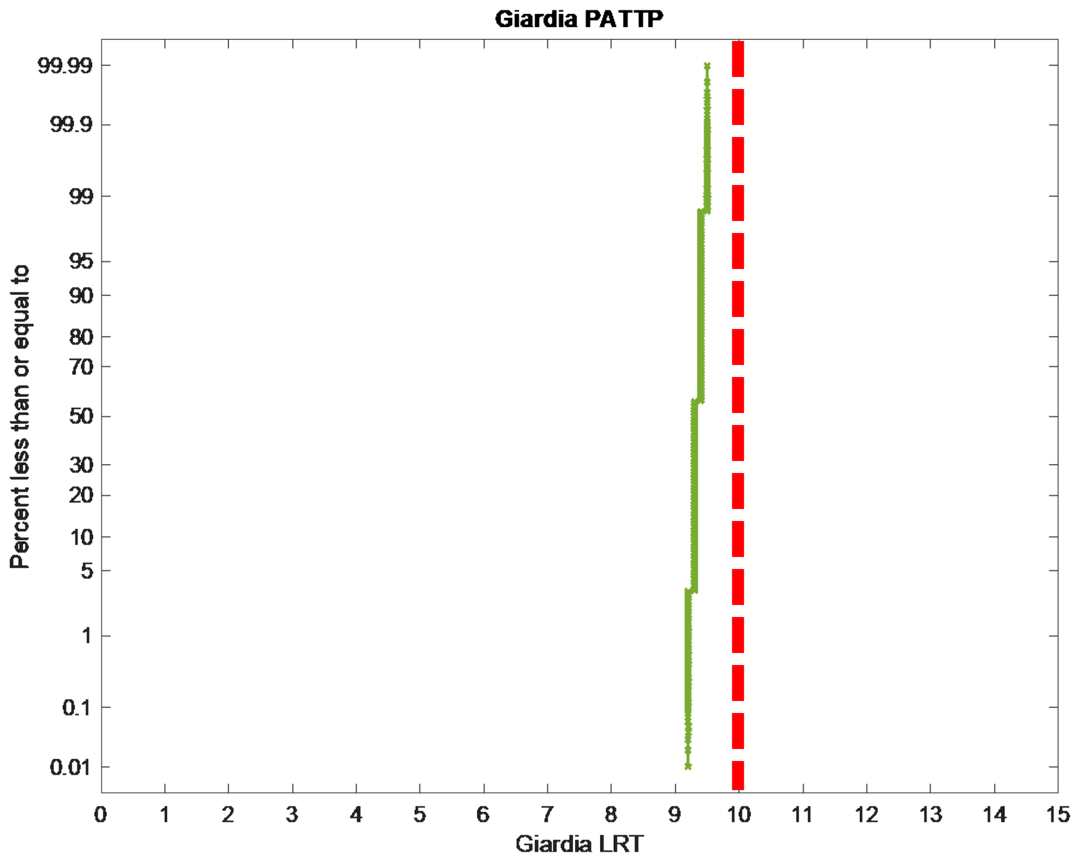


Giardia

Giardia Assumptions

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

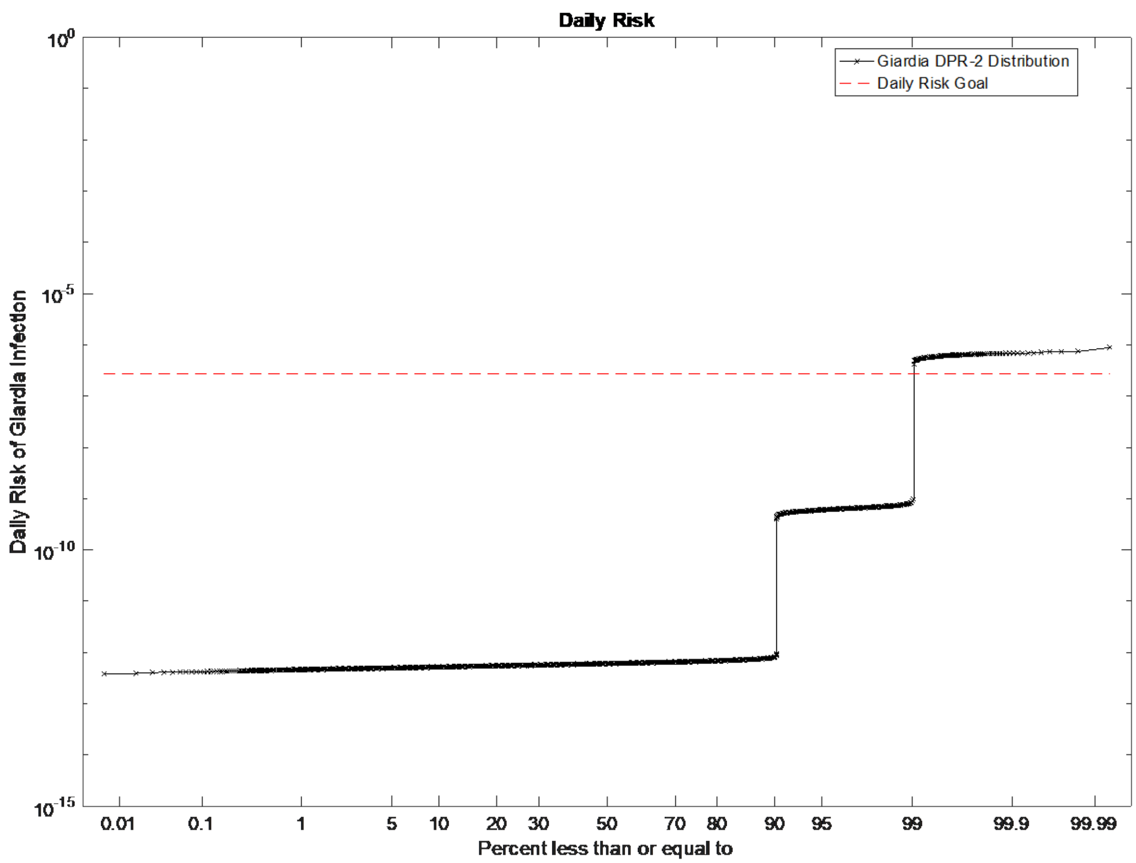
Giardia Required LRTs



Giardia LRT: 10

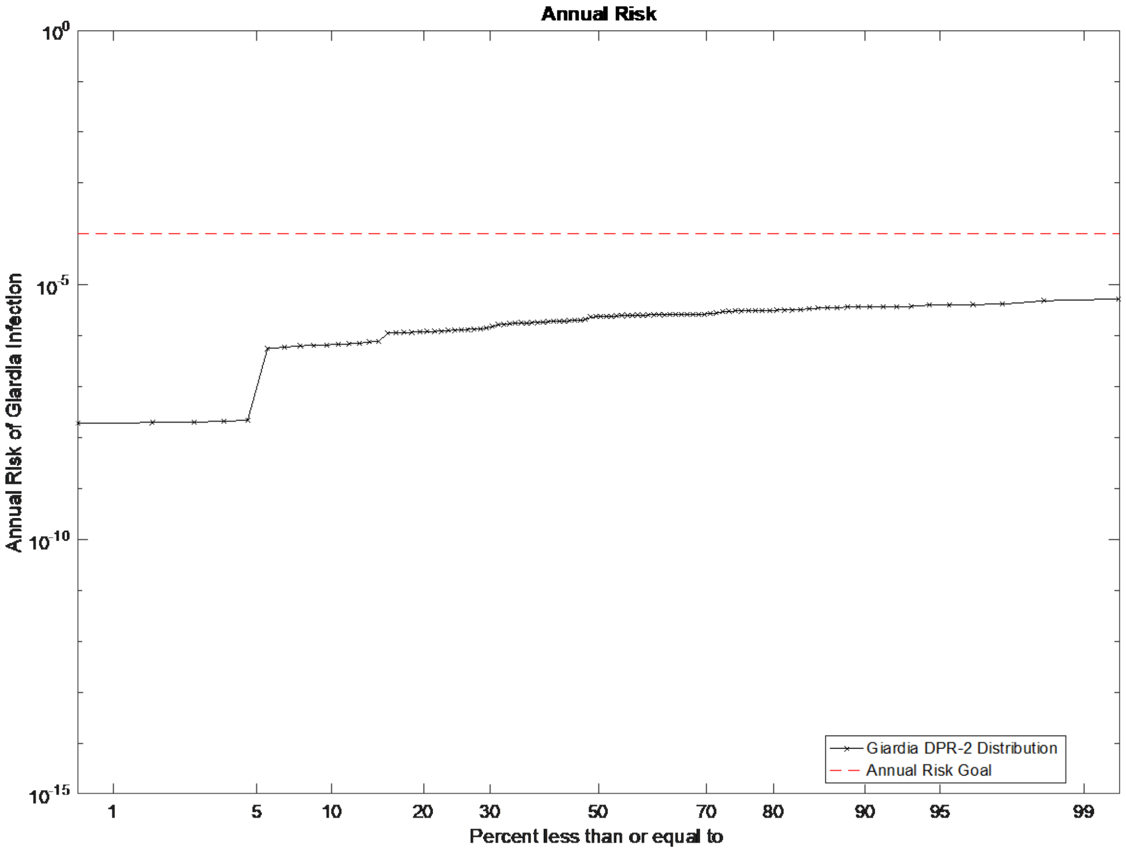
Giardia – Daily Risk with 5-log redundancy

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%

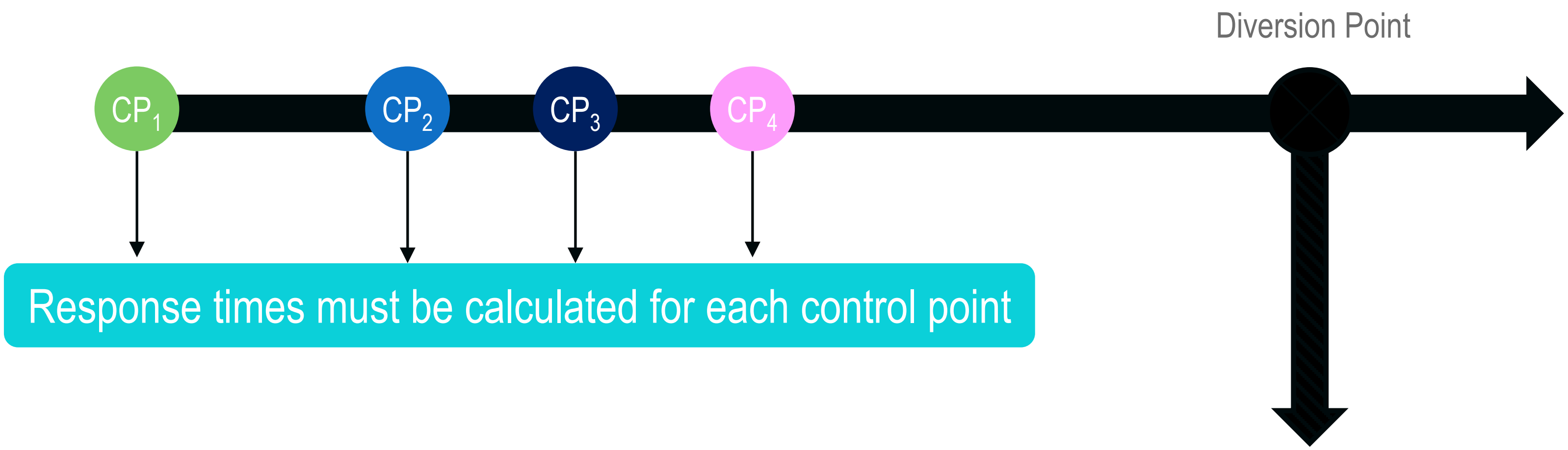


Potential Giardia Requirements

- Minimum treatment for public health protection: LRT = 10
- Minimum redundancy needed to address undetected 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%**

Compliance

Response Time – Current Approach



$$Response\ Time = \sum t_1, t_2, t_3$$

t_1 = time interval between online measurements

t_2 = time for SCADA to access data

t_3 = time for SCADA to implement a response:

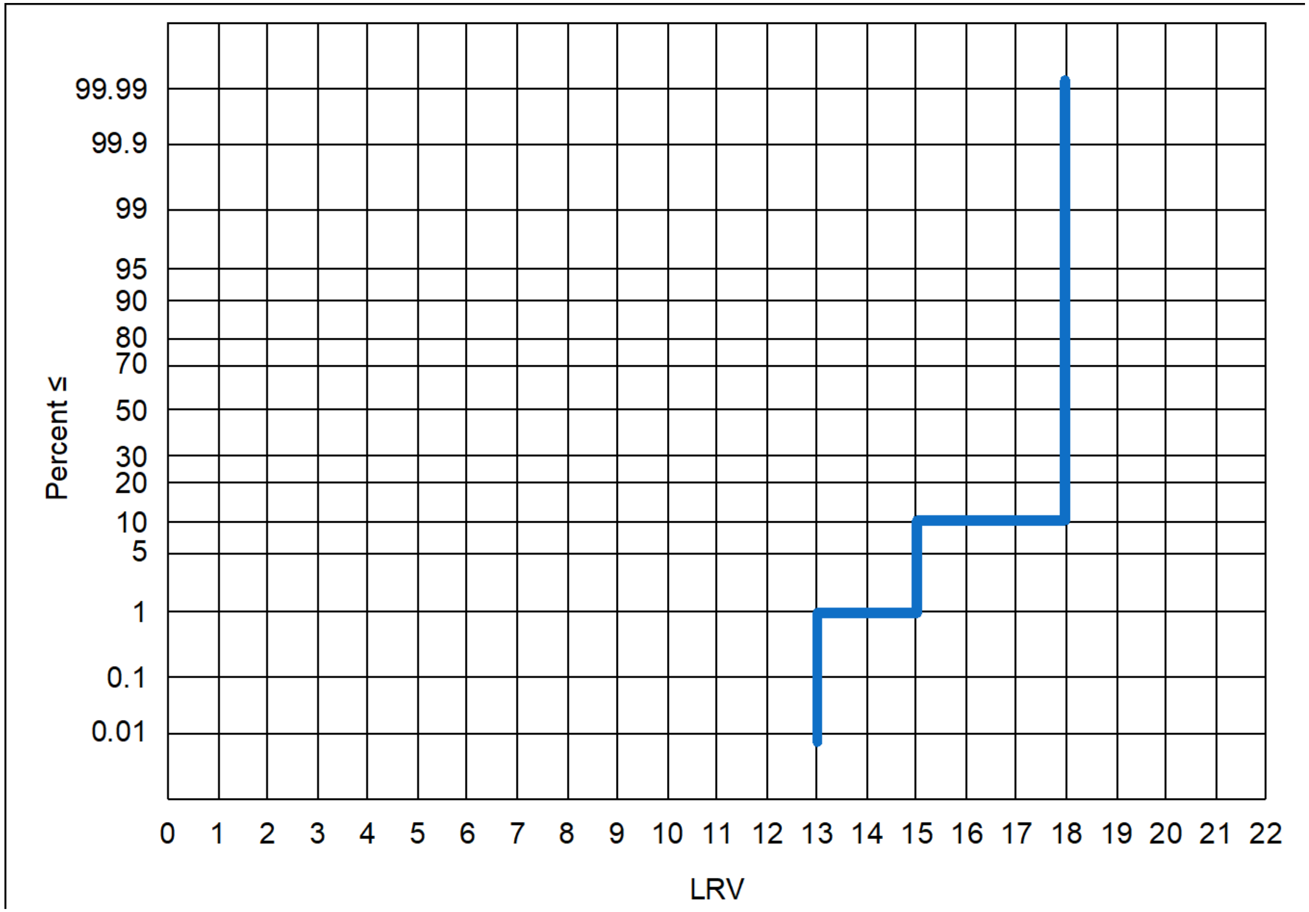
a. Determine an exceedance is occurring,
b. Actuate a diversion or shutoff valve, and
c. Divert or completely stop flow to distribution system

Source: WRCA June 2021

Example of potential compliance approach for virus

- Assume minimum LRV of 13 with 5-log required redundancy

- Compliance Approach
  - 1% at 13 LRV
  - 9% at 15 LRV
  - 90% at 18 LRV



IPR vs. potential DPR compliance framework

	IPR GWR	IPR SWA	DPR
Minimum LRVs for public health	12/10/10	12/10/10	13/10/10
Redundancy above public health limit	0-log	0- to 2-logs	5-logs
Required LRVs (minimum + redundancy)	12/10/10	12/10/10 - 14/12/12	18/15/15
Lowest allowable LRV	10/8/8*	10/8/8*	13/10/10
Tolerance for lowest LRV	Up to: a) 4 h consecutive, b) 8 h / week		Up to 1%

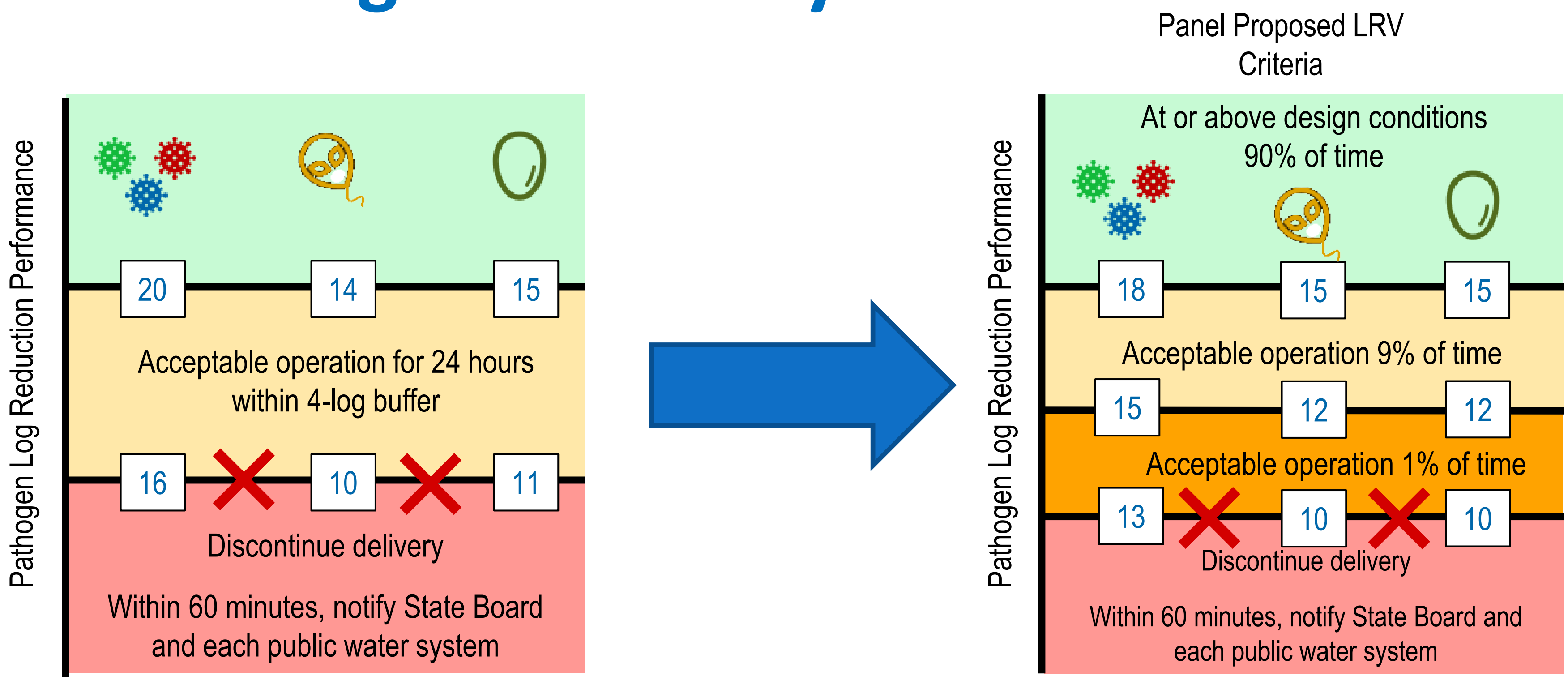
§60320.208. Pathogenic Microorganism Control.

(i) If a pathogen reduction in subsection (a) is not met based on the on-going monitoring required pursuant to subsection (d), within 24 hours of being aware a project sponsor shall immediately investigate the cause and initiate corrective actions. The project sponsor shall immediately notify the Department and Regional Board if the GRRP fails to meet the pathogen reduction criteria longer than 4 consecutive hours, or more than a total of 8 hours during any 7-day period. Failures of shorter duration shall be reported to the Regional Board by a project sponsor no later than 10 days after the month in which the failure occurred.

Panel Recommendations

- While the current DDW **LRV criteria** can be considered protective of public health additional analysis is recommended to address potential overengineering of treatment barriers and to conduct an intentional effort by SWB-DDW to require a reasonable number and combination of such barriers.
- The Panel recommends a probabilistic analysis utilizing the DPR -2 dataset rather than the static maximum point estimate approach for development of the LRVs.
- The Panel's 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 Panel proposed LRV criteria with 5-log redundancy



Next Steps (2022)

- **January 31** – Panel meeting with DDW staff to present and discuss Panel's comments and recommendations for pathogen control. (1.5 hrs allotted for DDW presentation and discussion and 0.5 hrs for Panel only discussion).
- **February 2** – Scheduled Pathogen workgroup (invite all Panel members) meeting to discuss any changes based on discussions with DDW staff (Tentative, if needed)
- **February 14** – Panel only meeting to review and discuss draft finding(s) including comments and recommendations (review draft slides for Panel report out at February Panel Meeting #4).
- **February 28** – Panel Meeting #4 – Report out Panel's Findings(s).
- **March (early)** – Draft Panel Finding memo to Panel for internal review (goal is to provide 1 week review time).
- **Mid March** – Panel Draft Finding memo to DDW.
- **April** (early)- Comments from DDW (allow 2 weeks review time).
- **April** (end) – Final Panel memo to DDW.

Questions?