

# Epsom Spring Gully Recycled Water Project - UV Disinfection Validation

The purpose of this document is to confirm the validation of ultraviolet (UV) disinfection capacity for the Bendigo Water Reclamation Plant, as well as the Pumping & Treatment Facility (PTF).

## 1 System Description

There is an existing open channel UV disinfection unit installed at the tertiary filters (Trojan UV3000Plus). A new open channel UV disinfection unit (Wedeco TAK 55 HP) is to be installed and commissioned as part of the water recycling project.

Approval has been received from the Victorian Department of Human Services, that these two units together provide 1 log adenovirus inactivation. This was calculated in accordance with the Draft USEPA Ultraviolet Disinfection Guidance Manual<sup>1</sup>, using the Tier 1 method. The design Reduction Equivalent Doses (REDs) and operating conditions provided by these units are summarised in Table 1 below:

**Table 1**  
**UV Disinfection Design Parameters**

Parameter	Trojan UV 3000Plus Unit	Wedeco TAK 55 HP Unit
Flowrate [L/s]	69.4 - 169.5	23.2 - 114.6
UV Transmittance [%]	56 - 68	56 - 76
RED [mJ/cm <sup>2</sup> ]	40.46 minimum	63.4 minimum
Number of lamps and lamp type	112 LPHO (Heraeus)	144 LPHO (Spektrotherm)
Banks x Modules x Lamps	2 banks x 7 modules x 8 lamps	3 banks x 4 modules x 12 lamps
Design lamp life [hours]	9,000	12,000
Design end of lamp life output [%]	98	87
Design fouling coefficient [%]	95	80

The inactivation capabilities of the two units are summarised against the Tier 1 criteria in Table 2, below:

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<sup>1</sup> USEPA, "Ultraviolet Disinfection Guidance Manual - Draft (EPA 815-D-03-007)", June 2003.

**Table 2**  
**Disinfection Capabilities based on UVDGM Tier 1 Criteria<sup>2</sup>**

Microorganism	Parameter	Trojan UV 3000Plus Unit	Wedeco TAK 55 HP Unit
<b>Adenovirus</b>	Required RED [mJ/cm <sup>2</sup> ] 0 Log red'n 0.5 Log red'n	23	23
		52.5	52.5
	Best fit: Log Red'n = 0.0173 RED [mJ/cm <sup>2</sup> ] - 0.414		
	RED delivered [mJ/cm <sup>2</sup> ]	40.5	63.4
	Disinfection capability [Log <sub>10</sub> ]	0.30	0.70
<b>Cryptosporidium</b>	Required RED [mJ/cm <sup>2</sup> ] 2.5 Log red'n 3.0 Log red'n	28	28
		36	36
	RED delivered [mJ/cm <sup>2</sup> ]	40.5	63.4
	Disinfection capability [Log <sub>10</sub> ]	3.0	3.0
<b>Giardia</b>	Required RED [mJ/cm <sup>2</sup> ] 2.5 Log red'n 3.0 Log red'n	26	26
		34	34
	RED delivered [mJ/cm <sup>2</sup> ]	40.5	63.4
	Disinfection capability [Log <sub>10</sub> ]	3.0	3.0

<sup>2</sup> USEPA, "Ultraviolet Disinfection Guidance Manual (EPA 815-D-03-007)", June 2003, Table 4.1, p 4-16

## 2 Validation Ranges

A comparison of validation versus proposed operational ranges is presented in Table 3, below:

**Table 3**  
**Validation Test versus Operational Ranges**

Parameter	Trojan UV 3000Plus Unit		Wedeco TAK 55 HP Unit	
	Validation Conditions	Operating Conditions	Validation Conditions	Operating Conditions
Flowrate [L.s <sup>-1</sup> .lamp <sup>-1</sup> .bank]	0.56 – 3.0	1.2 – 3.0	0.52 - 4.7	0.48 - 2.4
UV Transmittance [%]	52 – 69	56 – 68	53 - 75	55 – 75
UV Dose [mJ/cm <sup>2</sup> .bank]	11 - 125	≥ 40	12 - 100	≥ 63
Banks per channel	3	2	3	3
Modules per bank	4	7	2	4
Lamps per module	8	8	6	12
Power output [%]	60 *	60 – 100	70 *	50 – 100

\* Although validation only carried out at lower than maximum power, non-bioassay (intensity) investigations were carried out during validation to determine the relationship to determine performance at 100 % power.

For the Trojan unit, in order to avoid exceeding the maximum validated flow rate by 40%, its maximum operational flow rate has had to be reduced from 273.3 L/s to 169.5 L/s. Therefore, in the short-term the unit will be operated at or below the validated limit. Options to increase the validated limit are as follows:

- Validate the existing Trojan UV unit on-site at flow rates at and above 3.03 Ls<sup>-1</sup>.lamp<sup>-1</sup>.bank;
- revalidate the tertiary filters, to achieve greater virus and protozoan parasite removal.

A decision is yet to be made regarding the best course of action. In the interim, the validated maximum flowrate of 169.5 L/s will be the operating limit.

## 3 Critical Limits

### 3.1 Lamp Failures

#### 3.1.1 Trojan UV3000Plus Unit

If lamp failure occurs while only one bank is in operation (due to low flow and/or high transmissivity), change duty bank, otherwise the following CCLs will prevail.

- Due to the fact that the lamps are wired in pairs, failure of one lamp causes both of the lamps in that pair to fail. Failure of 2 lamps in one bank results in a reduction of the flow area disinfected of 3.6% (2 lamps/56 lamps). To accommodate the associated

reduction in dose, the flow will be reduced by 3% in accordance with the dose/flow relationship determined in the validation. If 4 lamps fail (2 in one bank, and 2 in the other) the flow will be reduced by 12%.

- If the unit is operating at its interim maximum flow (169.5 L/s), the flow needs to be reduced in direct proportion to the number of lamps that have failed per bank (i.e. 3.6%) whether it is for 2 lamps on one bank or 4 lamps (2 in one bank, and 2 in the other).

If more than two lamps fail per bank, shut down Class A train.

### 3.1.2 Wedeco TAK 55 HP Unit

If lamp failure occurs while only one or two banks are in operation (due to low flow and/or high transmissivity), change duty bank. If three banks are in operation the following CCLs will prevail:

- As for the Trojan unit - the lamps are wired in pairs and therefore failure of one lamp causes both of the lamps in that pair to fail. Failure of 2 lamps in one bank results in a reduction of the flow area disinfected of 4.2% (2 lamps/48 lamps). To accommodate the associated reduction in dose, the flow will be reduced by 2% in accordance with the dose/flow relationship determined in the validation.
- If 4 lamps fail (2 in one bank, and 2 in the second bank) the flow will be reduced by 4%.
- If 6 lamps fail (2 in one bank, 2 in the second, 2 in the third) the flow will be reduced by 6%.

If more than two lamps fail in any bank, shut down Class A train.

## 3.2 Variation in Water Surface Level

This uncertainty is incorporated into the UVDGM unquantified uncertainties, alongside variables such as flowrate measurement error, etc.

### 3.2.1 Trojan UV3000Plus Unit

Lamp spacing 88.9 mm. 8 lamps x 88.9mm = 711 mm deep.

Normal Water Surface Level (NWSL) at outlet is 33 mm above top of top lamp.

Run last bank with WSL 1 mm from top of top lamp to + 12 mm above this level (Max WSL). This is 21 mm below NWSL.

Upstream of first bank Max WSL is an extra 9 mm above NWSL (i.e. 31 mm - 21 mm above NWSL, or 9 mm).

If the Max WSL is 9 mm above NWSL, the area not disinfected is  $9/711.2 = 1.3\%$ .

To ensure the result is conservative, double these figures, as the flow is not affected by drag at the top (boundary condition  $v = 0$  m/s only occurs on the bottom and side walls). Loss in disinfection is 2.6 % percent depending on how many banks are operating.

The low level alarm should be set at -32 mm and high level +9 mm from Normal Water Surface Level, which is equivalent to +1 mm and +39 mm above top of top lamp at outlet.

### **3.2.2 Wedeco TAK 55 HP Unit**

Lamp spacing 120 mm.

Normal Water Surface Level (NWSL) at outlet is 31 mm from top of top lamp.

Run last bank with WSL 1 mm from top of top lamp to 61 mm above this level (Max WSL). This is 30 mm above NWSL.

Upstream of first bank Max WSL is an extra 30 mm above Max WSL (i.e. 30 + 31 mm above NWSL). This is obtained by adding UV unit head loss to the 30 mm dimension.

If the Max WSL is 30 mm above NWSL, the area not disinfected is  $33/710 = 4.2\%$ .

To ensure the result is conservative, double these figures, as the flow is not affected by drag at the top (boundary condition  $v = 0$  m/s only occurs on the bottom and side walls). The total loss of disinfection is 8.4 %.

The low level alarm should be set at -30 mm and high level +30 mm from Normal Water Surface Level, which is equivalent to +1 mm and +61 mm above top of top lamp at outlet.

## **3.3 Intensity Sensor Fault**

### **3.3.1 Trojan UV3000Plus Unit**

The intensity sensor is not used for control, but is used to alarm in the event of low UV intensity.

### **3.3.2 Wedeco TAK 55 HP Unit**

The intensity sensor is not used as part of the dose control algorithm, but is used to alarm in the event of low UV intensity.

## **4 Validation Reports**

The third party validation reports supplied by Trojan and Wedeco were provided on a strictly commercial-in-confidence basis. To protect the undertakings made to the suppliers regarding confidentiality, these reports are not included here but have been separately provided to DHS.