Notes:
Velocity profiling can be performed in lieu of a CPB.
No CPB is required if complaint with points 1 thru 7 (as appropriate).
Compliance with item 5 requires CFD modelling or site velocity profiling.
CFD modelling must comply with the 2006 UVDGM Appendix D guidelines.

	Issue	Checklist Item	Comment / Recommended change	Rationale	Scientific reference	Recommended Check List Compliance Criteria
1	Scale Up - Closed vessel reactors	Valid Bioassay	For pressurized UV reactors performance cannot be scaled to different sized reactors.	The flow and UV light fields will differ between reactors.		3rd party bioassay validation following NWRI protocol. Scale up not acceptable.
2	Scale Up - open channel reactors	Valid Bioassay	Open-channel UV reactors with uniform lamp spacing are a special case of reactors that can be scaled due to modularity, given certain constraints. the modularity translates to uniform lamp arrangements and lamp spacing's between smaller and larger versions.	See NWRI guidelines	Results of CPBs from nine different sites for 3000+ open-channel modular UV reactor demonstrated that the CPB and predicted MS2 doses were well correlated, with a slope near to unity and a high coefficient of determination (r2 = 0.8707). The strength of this relationship together with the uncertainty inherent in full scale testing the scale-up assumption is effectively proven to be valid for modular open-channel UV reactors. Trojan Technologies paper "UV System Checkpoint Bioassays: Proof of Scale-up, Challenges from the Field, and Comparison Methodology".	3rd party bioassay validation following NWRI protocol. Scale up limited to 10x as per NWRI protocol.
3	Site Issue - Inlet hydraulics to reactor	Providing adequate stilling basin(s)/well(s) leading into UV channels	1) Need to restrict inlet jet velocity of inlet pipes therefore size inlet pipes for a maximum of 1.5 m/s max pipe velocity. 2) Size inlet well to adequately dissipate energy of inlet jet and avoid aiming directly into UV channel by incorporating a minimum size of: - Depth sufficient to locate inlet pipe 1.5 to 2.5 pipe diameters below floor of UV channel - Width at 1.5 x the UV Channel width x number of Channels in parallel - Length at the greater of the UV Channel width or nominal depth.	Helps to keep head loss, large scale turbulence and flow field distortions to manageable levels		Inlet pipe velocity ≤ 1.5 m/s. Inlet well dimensions meet comments 1) & 2).
4		Avoid sharp turns/bends/edges within 3 x Hydraulic Diameters of 1st UV bank	Locate 1st Bank with sufficient lead-in distance. 1) Set lead-in distance at least 3 hydraulic diameters downstream of Inlet Well where hydraulic diameter is defined as 4 x Rh where Rh = Hydraulic Radius = Flow cross section/wetted perimeter 2) Avoid Inlet Edges and Bends/Elbows. Chamfer or round edges and corners approximately equal to Rh of UV Channel.	1) Reduces risk of UV Banks being in location with flow trips and/or recirculation zones. Use of hydraulic diameter allows the lead-in to scale with reactor size and hence maintain similar inlet hydraulic conditions regardless of scale-up of reactor 2) If possible, Chamfers & rounding of inside corners (e.g. 8x8 to 12x12 inch chamfers and 12" rounding) helps to reduce distortion of velocity profiles leading into reactor.	The intent of these points is to the keep velocity profiles leading into reactors to within adequate tolerances and to ensure impact on expected and/or validated reactor performance remains negligible	1st UV bank lead in distance ≥ 3 hydraulic diameters. Chamfers and rounding inside corners done - Yes.
5		If sharp turns/bends/edges cannot be avoided provide adequate flow conditioning to remove the their effects	1) Use one or more perforated plates each with between 40 to 60% open area to correct velocity profiles. 2) If necessary use guide vanes to correct flow field distortions due to turns or bends within UV Channels	1) Avoid perforated plates with less than 40% open area since they can produce their own flow distortions and recirculation zones. Space multiple perforated plates at least 5 to 6 times the hole diameter of perforations; this allows sufficient spacing for individual jets to recombine ahead of subsequent plates in order to achieve maximum flow field correction with minimal footprint. 2) Design of guide vanes should be performed by specialists expert in hydrodynamic and/or hydraulic design.		Perforated plate(s) in compliance to points 1) & 2)

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6		Water Level Check	Confirm the level control device(s) is set up at manufactures recommended elevation relative to reactor. Also confirm that Level Control Devices across multiple channels are located at the same elevation.	Incorrect weir set up can result in water level exceeding design limit and having short circuiting over the UV bank. Elevation offsets of level control devices across multiple channels can produce large flow imbalances which can negatively affect disinfection performance and discharge capacity.	Elevation effects in Multi-channel arrangements can results in different hydraulic gradients among channels which results in flow imbalances.	Confirm Level Control Device is installed & set properly as per manufacturer's instructions. Measure water level at the design flow rate for all UV banks and ensure level is less than the UV manufactures maximum water level limit for all UV banks. In multi-channel applications confirm elevation of Level Control Devices is within manufacturer's required tolerances. Any expected residual imbalance should be accounted for in overall design and sizing of system by consulting engineers.
7	Site Issue - off specification civil works	Channel Construction Tolerance	Because modular UV reactors are designed and manufactured with precise lamp spacing's, it is necessary that those same spacing's are maintained at reactor edges (channel walls and channel bottom). If civil works are completed out of specification (out of tolerance), then the lamp spacing's at the edges of the UV system will not be at design values.	If the channel walls are built too wide, or the channel bottom elevation is too deep, then lamp spacing's at UV reactor edges will be larger than design and zones with UV intensities lower than design will be created. Microbes travelling through the low intensity zones will receive relatively low UV doses, and a higher number of survivors will exit the UV reactor. Ultimately, the population of microbes passing through the reactor will contain a higher proportion of survivors, and the corresponding overall UV dose will be necessarily lower (as dose is defined in terms of microbiological inactivation).	Results of CPBs showed that banks in channels have been found installed too high and, in others, channels built too wide/deep. As mitigation, the UV module support structures were re-installed returning the spacing at the bottom to the design value. For the other, the channel width/depth was corrected. Repeated CPB's confirmed that the performance of all banks were at expected levels after civil/installation works were returned to recommended tolerances.	Channel civil works within construction tolerance stated by manufacturer for all UV banks. Reactor installation is within tolerances stated by the manufacturer.
8	Site Testing Issue - CPB Testing Protocols met (steady state & water quality)	CPB Protocols	There are numerous details that must be considered to ensure accurate CPB results. Without proper appreciation for all of the requirements of accurate measurements and assignment of performance to accurate conditions (flow rate and water quality), CPBs can result in misleading information.	See NWRI guidelines	See NWRI guidelines; Trojan Technologies paper "UV System Checkpoint Bioassays: Proof of Scale-up, Challenges from the Field, and Comparison Methodology".	3rd party bioassay validation following NWRI protocol including the following protocol steps: tests to determine the time to reach steady state; mixing tests to prove that the position of the upstream sampling port is appropriate; mixing tests to prove that the position of the downstream sampling port is appropriate; the verification of flow meter accuracy; the verification of UV transmittance monitor accuracy; approved method to monitor flow stability and water quality stability during testing to ensure the maintenance of steady state; documented & approved microbiological sample handling; documented & approved UV collimated beam methodology.
9	Site Testing Issue - CPB Dead Zones	CPB Dead Zones	Any branches in piping or channels that do not have through flow will be dead zones that will complicate steady state.	Dead zones can lead to erroneous results because they can be transient sources or sinks of microbes that can contaminate samples in later tests.		Site CPB process flow chart documenting all piping/channels, etc. and all possible dead zones identified. CPB testing protocol to document how each potential dead zone will be mitigated to not impact test and how they will be mitigated during the CPB test.
10	Site Testing Issue - CPB Data Accuracy	CPB Results Accuracy	Utilizing CPB data at face value without consideration of whether it has a bias (e.g. flow or UV transmittance offset) or whether it has lower accuracy than the data it is being compared to will result in incorrect determination of pass/fail (criteria).	The accuracy or uncertainty of the CPB results should be estimated. The uncertainty should be used in comparisons to product validation efforts.	UV systems could be judged by whether their CPB results fall within an acceptable band that could be based upon statistics or upon a sensitivity analysis (how much is dose expected to change if the UVT or the flow were different by a given amount)	
11	CPB Pass Fail Criteria	CPB Pass	TBD	TBD	TBD	Pass / fail criteria are under consideration by NWRI. Current pass fail criteria methodology is not well defined and needs to be further clarified by NWRI.

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