This document is released for the purpose of information exchange review and planning only under the authority of Hugh Steve McDonald, December 2015, State of California, PE No. 44074 and Tracy Anne Clinton, December 2015, State of California, PE No. 48199

City of Oxnard

Public Works Integrated Master Plan

RECYCLED WATER

PROJECT MEMORANDUM 4.6 PATHOGEN ANALYSIS FOR DIRECT POTABLE REUSE

FINAL DRAFT
December 2015

2700 YGNACIO VALLEY ROAD • SUITE 300 • WALNUT CREEK, CALIFORNIA 94598 • (925) 932-1710 • FAX (925) 930-0208
pw:\\Carollo/Documents\Client/CA/Oxnard/9587A00/Deliverables/PM Deliverables/PM 04 Recycled Water System/Final Drafts\PM 4.6

City of Oxnard

Public Works Integrated Master Plan

RECYCLED WATER

PROJECT MEMORANDUM 4.6
PATHOGEN ANALYSIS FOR DIRECT POTABLE REUSE

TABLE OF CONTENTS

Page No.

LIST OF TABLES

PATHOGEN ANALYSIS FOR DIRECT POTABLE REUSE

1.0 BACKGROUND

Indirect potable water reuse (IPR) projects in California are required to attain 12-log removal of virus and 10-log removal of protozoa from the point of raw wastewater to the point of potable water consumption (CDPH, 2014). Direct potable reuse (DPR) projects will be required to attain a similar or even higher level of pathogen removal. Pathogen removal will come through various treatment processes, including primary/secondary treatment, low pressure membrane filtration (MF or UF), reverse osmosis, and UV advanced oxidation. This review deals only with the removal of pathogens through primary and secondary treatment.

The existing data on pathogen levels in raw wastewater and the removal through primary and secondary treatment is limited, as is the ability to continuously or periodically monitor treatment process performance using online or grab-sample monitoring methods. Understanding pathogen concentrations prior to advanced treatment is a critical step in safely implementing potable water reuse. One of the most recent California Division of Drinking Water (DDW) approval of pathogen removal credits for combined primary and secondary treatment was obtained by the Water Replenishment District of Southern California (WRD, 2013). That document relied upon risk analysis data presented by Olivieri *et al.* (2007) which was developed based upon research by Rose *et al.* (2004). Rose *et al.* (2004) defined the range of bacteria, enterovirus, *Cryptosporidium*, and *Giardia* removal through six different full-scale wastewater treatment plants. The raw data from that work is reported by Olivieri *et al.* (2007) and shown in Table 1. At WRD (2013), the secondary process pathogen removal credits were based upon the data from two of the six tested secondary process configurations. Specifically, two of the secondary process trains (Facilities C and D, with solids retention times (SRTs) of 1.6 to 2.7 days and 3 to 5 days, respectively) had SRT values less than the secondary process feeding the WRD advanced treatment system (>9 days), and thus are presumed to be conservative estimates of performance. Per DDW request, WRD (2013) used the lower 10th percentile values calculated for each pathogen, resulting in 1.9-log reduction of enterovirus, 1.2-log reduction of *Cryptosporidium*, and 0.8-log reduction of *Giardia*.

Table 1 Pathogen Reduction Values Through Primary and Secondary Treatment (from Rose *et al.*, 2004)
Public Works Integrated Master Plan
City of Oxnard

Lower 10th Percentile Values		**Log Reduction**		
SRT	**Facility**	**Enterovirus**	***Giardia***	***Crypto***
1.6-2.7	C	1.8	2.6	1.25
3-5	D	2.05	1.35	1.4
3.5-6	B	1.95	2.45	1.6
6-8	A	1.65	0.8	0.7
8.7-13.3	E	1.75	2.6	1.9
8-16	F	2.6	0.9	0.25
1.6-16	**ALL**	**1.85**	**0.8**	**1.2**
50th Percentile Values		**Log Reduction**		
SRT	**Facility**	**Enterovirus**	***Giardia***	***Crypto***
1.6-2.7	C	2.05	3.05	1.65
3-5	D	2.5	1.9	2.6
3.5-6	B	2.25	2.6	1.9
6-8	A	2.1	1.6	1.1
8.7-13.3	E	2.2	2.8	2.1
8-16	F	2.75	1.1	0.95
1.6-16	**ALL**	**2.3**	**2.6**	**1.6**

2.0 PATHOGEN REMOVAL RESEARCH PLAN

This new research with the City of Oxnard is intended to document the pathogen concentrations in raw wastewater and the removal of pathogens through primary and secondary treatment at the Oxnard Wastewater Treatment Plant (OWTP). This new research will also examine potential surrogates for pathogen removal, measurements that can demonstration pathogen removal performance without the expense or time requirements for actual pathogen sampling and analysis. Table 2 summarizes the planned new research.

Table 2 Removal Through Primary and Secondary Treatment Test Plan
Public Works Integrated Master Plan
City of Oxnard

Analyte	Method	Lab	Raw Wastewater, Oxnard	Secondary Effluent, Oxnard	No. of Samples per Month	No. Months of Testing
Male Specific Phage and Somatic Phage	Double Layer (Adams,'59)	BioVir	X		2	3
Male Specific Phage and Somatic Phage	US EPA 1602	BioVir		X	2	3
Enterococci	US EPA 1600 (MF)	BioVir	X	X	2	3
Giardia/Cryptosporidium	EPA 1626	SNWA	X	X	2	3
Virus: Norovirus, Enterovirus, total culturable virus (Coxsackievirus, Echovirus, Rotavirus, Reovirus)	EPA 1615 Tissue Culture with RTQPCR	BioVir	X	X	2	3
BOD	BOD5	Oxnard	X	X	2	3
TOC	SM 5310B	SNWA	X	X	2	3
UVA	SM 5910B	SNWA	X	X	2	3
Fluorescence	McKnight *et al.*, 2001	SNWA	X	X	2	3

3.0 RESEARCH RESULTS

The new research is being conducted as part of WateReuse Research Foundation (WRRF) Project 14-16. Six sampling rounds are scheduled, and the first round has been completed and the data included here in Figure 1. Data is too preliminary to make any substantial conclusions beyond the obvious reduction of pathogens through the secondary process and improvement in water quality based upon TOC, UVA, and fluoresence.

Sample Site	Sample Date	DOC	TOC	UVA_{254}	UVT_{254}	UVA_{280}	Phage, male specific	Phage, Somatic	Entero.	E. coli	Total Coliform	Giardia	Crypto	Total Culturable Virus	Enterovirus	Norovirus GIA	Norovirus GIB	Norovirus GII
		(mg/L)	(mg/L)	(cm^{-1})	(cm^{-1})	(cm^{-1})	(pfu/100 mL)	(pfu/100 mL)	(org/100mL)	(MPN/100mL)	(MPN/100mL)	(cysts/L)	(Oocysts/L)	(MPN/L)	(GC/L)	(GC/L)	(GC/L)	(GC/L)
Secondary Effluent	08/18/15	12	15	0.22	60.5	0.17	670	1,700	>2419.2	>2419.2	>2000	4.31	1.54	0.28	620,000	360,000	42,000	16,000
Raw Wastewater	08/18/15	69	82	0.69	20.6	0.45	5,700	3,100	4,300,000	41,000,000	160,000,000	6,500	Footnote 1	<3.3	1,100,000,000	130,000,000	4,500,000	1,600,000
Notes																		
1. The extremely high solids content in the raw wastewater and the small size of Cryptosporidium make enumeration difficult and accurate enumeration impossible.																		
2. Log removal of Cryptosporidium assumed to be similar to log removal of Giardia.																		

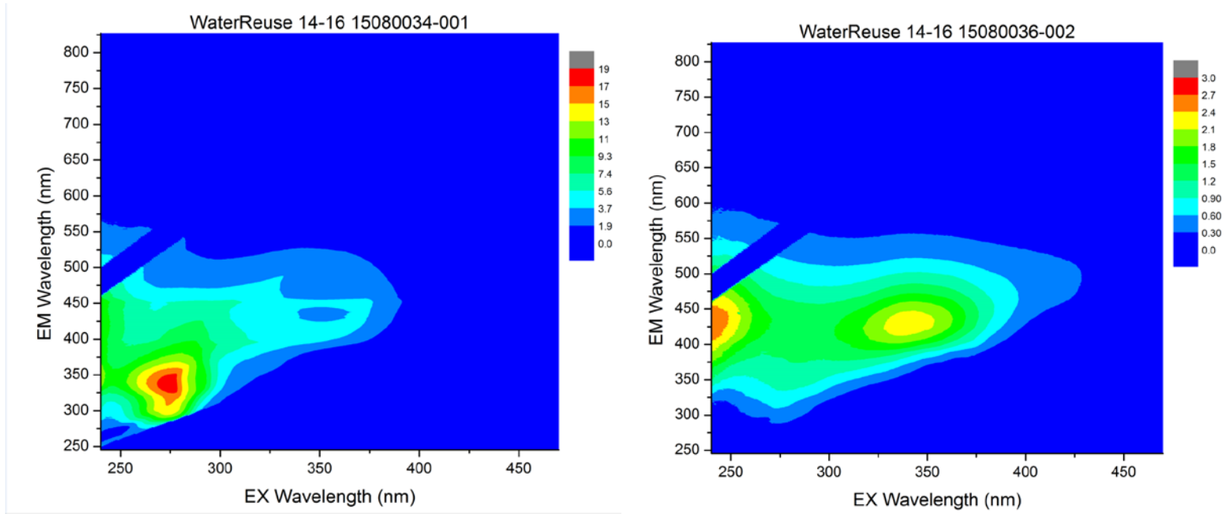

Figure 1 Preliminary Data from First Sampling Round