Subject	**Willamette River Outfall Diffuser Siting Alternatives Evaluation (Task 3.4.2.1)**
Project Name	Tri-City WRRF Willamette River Outfall Project
Jacobs PN	D3218600
To	Jeff Stallard, PE/WES Lynne Chicoine, PE/WES
From	David Wilson/Jacobs Brad Paulson/Jacobs Don Kingery/Jacobs
Date	February 18, 2020
Reviewed by	Quitterie Cotten/Jacobs

1. Introduction

This Technical Memorandum (TM) is provided to address Task 3.4.2.1, Diffuser Siting Alternatives Evaluation, defined in the engineering services contract for the Tri-City Water Resource Recovery Facility (WRRF) Willamette River Outfall Project with Water Environment Services (WES). This technical evaluation is focused on alternative outfall diffuser sites and potential river outfall routes from the shoreline to each diffuser alternative.

1.1 Background

Flow to the Tri-City WRRF Outfall that discharges into the Willamette River is approaching its hydraulic capacity of 75 million gallons per day (mgd) and the WRRF requires a second outfall to the Willamette River to accommodate anticipated increased flows. Flows to the WRRF are projected to reach 121 mgd by 2040 and 176 mgd at buildout, according to the recently completed Clackamas County Sanitary Sewer Master Plan for Water Environment Services (Jacobs, 2019) if I/I reductions recommended in the Master Plan are achieved. The additional outfall capacity will be constructed to accommodate buildout flow.

The key objectives of the Tri-City WRRF Willamette River Outfall Project are as follows:

1. Determine the best alignment for the new effluent pipeline and river outfall that carefully considers routing and schedule constraints and cost.
2. Provide diffuser siting in the Willamette River based on existing and historical river bedform conditions and a diffuser design that allows for future adaptations to changes in river bedforms and seasonal flow changes.
3. Provide a new outfall diffuser design that optimizes dilution performance to meet river water quality standards.
4. Successfully design and permit the work to allow construction as early as 2022 and discharge operation in 2023.

The design development of the outfall and diffuser in the Willamette River requires assessment of physical site conditions (including the shoreline and submerged river regions), and physical forces at potential diffuser sites including riverbed transport mobility and ambient currents. The outfall and diffuser site selections and diffuser design will be based on physical site conditions (existing and historical changes) in the Willamette River and permitting and public use considerations. Feasible and recommended diffuser sites are identified in this TM, and the selection of the diffuser site and outfall route into the river will be the next step for WES. The evaluation and recommendations for the overland outfall routes to the river shoreline have been presented in the *Segment 2A and 2B Routing Alternatives Evaluation Technical Memorandum* (Jacobs, December 12, 2019). Jacobs and WES will work together to develop a common shoreline connection point for the overland and river outfalls.

1.2 Scope and Approach

This diffuser siting alternatives evaluation has applied data and results developed in the following project tasks: review of existing data for the Willamette River (Task 2.1), data collections on the Willamette River (Task 2.2), Willamette River bedform analysis of historical geomorphology of the shoreline and riverbed, current bathymetric and bed sediment conditions, and analysis of potential for river bedform changes with high river flows (Task 2.2), and preliminary conceptual diffuser dilution modeling (Task 4.2.2). Technical memoranda that provided river data summaries, hydraulic modeling results, river stage and flow statistics, and river bedform analyses that contributed to this document include:

Willamette River Site Characteristics TM (Task 2.2.4)

River Bedform Analysis TM (Task 2.2.3)

The scope of this evaluation is to conduct preliminary evaluations and compare up to four alternative diffuser sites and river outfall route alignments from the shoreline to the diffuser site. This evaluation also includes development of a preliminary matrix of the diffuser and route alternatives.

The Willamette River outfall diffuser siting evaluation approach included the following steps:

1. Define diffuser siting and river outfall route evaluation criteria to use in screening river sites
2. Review current and historical Willamette River bathymetry data to identify stable outfall diffuser sites that meet the evaluation screening criteria
3. Apply the river channel geomorphology and stability assessment to identify river channel sites with stable bed under flood flows and preferred bed geometry for the diffuser site
4. Conduct preliminary outfall diffuser configuration development for preliminary dilution modeling to allow assessment of dilution performance for plausible outfall diffuser configurations in the project reach
5. Conduct preliminary dilution modeling of plausible outfall diffuser configurations in the project reach to establish performance threshold
6. Review Willamette River bathymetry, constructed features, and shoreline features to identify suitable outfall pipe routes to each alternative diffuser site that meet the evaluation screening criteria
7. Develop a matrix comparison of outfall routes and diffuser site alternatives

2. Site Evaluation Criteria and Feasibility Screening

2.1 Site and Route Evaluation Criteria

Diffuser siting and river outfall route evaluation criteria were developed to use in screening and identifying suitable Willamette River sites and routes. The logical progression of outfall and diffuser siting starts with identifying suitable diffuser sites followed by identifying plausible and efficient river outfall routes to link to the diffuser sites.

Table 1. Screening Criteria for Diffuser Sites and River Outfall Routes in the Willamette River

Subject	Screening Criteria	Application
Diffuser Site Screening	Location in river cross-section	Avoid potential use conflicts
	Water depth range at site	Effectiveness of diffuser dilution performance
	Geometry to install diffuser	Effectiveness and constructability
	Riverbed materials	Structure stability and avoid burial or scour
	River current velocities	Effectiveness of diffuser dilution performance

Table 1. Screening Criteria for Diffuser Sites and River Outfall Routes in the Willamette River

Subject	Screening Criteria	Application
	Absence of wood debris piles	Safe site to avoid damage and maintenance
	Dilution performance at critical flows	Dilutions to minimize/avoid effluent limits
Outfall Route Screening	Proximity to diffuser site from shore	Construction cost effectiveness
	In-river structures or obstacles	Avoid construction conflicts and cost additions
	Shoreline structures and uses	Avoid construction conflicts and cost additions
	Riverbed materials	Structure stability and constructability

2.2 Initial Feasibility Screening of Diffuser Sites

Early project screening of potential outfall diffuser sites included river water depths, distance from the WRRF, physical and infrastructure obstacles, and discharge permitting barriers. Based on the early screening of outfall diffuser sites the following sites were eliminated:

- Clackamas River (no new discharges under OAR 340-041-0350 - Three Basin Rule);
- Willamette River downstream of confluence with Clackamas River (unstable river bed elevations over time and distance from WRRF);
- proximity to existing Outfall 001 (shallow river bed elevations); and
- Willamette River near the Highway 43 bridge (distance from WRRF and infrastructure obstacles).

Based on the early project screening of suitable outfall diffuser sites in the Willamette River Bedform Analysis TM (Task 2.2.3) and the Willamette River Site Characteristics TM (Task 2.2.4) have been focused on potential new outfall diffuser sites within approximately 1,500-foot reach of the Willamette River from 500 feet upstream of the Abernethy Bridge to approximately 1,000 feet downstream of the bridge.

Riverbed conditions were characterized based on available historical data and data collected during field studies in June 2018 conducted by SHI as part of the Oregon Department of Transportation (ODOT) Abernethy Bridge Project and in July 2019 for this project. The data collected focused on the site bathymetry and observed changes in bottom features at the site, site hydrology, and characterization of riverbed sediments are presented in the *Willamette River Bedform Analysis Technical Memorandum – Task 2.2.3* (Jacobs, February 2020).

Figure 1 provides a detailed chart of Willamette River bathymetry in the potential new outfall diffuser region. Two potential feasible diffuser regions are shown in Figure 1, one upstream of the Abernethy Bridge and one larger region downstream of the bridge. The deepest water depths in this river reach are under the bridge span, but with ODOT's plan to widen the bridge there will be construction trestles installed on piles both upstream and downstream of the bridge and construction barges anchored alongside the bridge piers. Therefore, routing and constructing an outfall and diffuser under the bridge is considered infeasible and entails too much risk of damage.

The potential diffuser region upstream of the Abernethy Bridge has a potentially feasible diffuser site in the deepest portion of the river channel. However, the outfall routes to this diffuser region have significant conflicts including crossing Abernethy Creek, transecting through the Sportsman Landing Marina, transecting through area where construction trestles will be installed upstream of the bridge, and requiring a very deep excavation or boring to maintain the pipe grade for a gravity discharge. For these reasons, the upstream region was eliminated from the diffuser site evaluation.

The larger region downstream of the bridge (shown in Figure 1) has been the region of focus to develop feasible diffuser sites and outfall routes.

The *Willamette River Bedform Analysis Technical Memorandum – Task 2.2.3* (Jacobs, February 2020) provides key input to this diffuser siting evaluation, including the use of site-specific field data in bed stability assessment and sediment transport modeling analysis, the summary of an understanding of short-term and long- term geomorphic processes in the project reach, and results on river channel stability to support placement for the planned river outfall and diffuser. The optimal diffuser placement is a site with stable bathymetry over decades and with bed characteristics that have low probabilities to mobilize under flood river flows. The findings of the Willamette River bedform analysis are summarized as follows:

1. Analysis of channel stability and bed mobility/transport potential included a review of available data as well as additional field data collection of site bathymetry, river flows, water levels, and sediment characteristics. A hydrodynamic model was created using observed stage and discharge to estimate hydraulic conditions such as water velocities and bottom shear stresses throughout the project site for various flow scenarios to understand the river flow conditions and locations where riverbed mobilizations can occur.

2. Based on the results of these analysis, it is concluded that the bed is generally stable, particularly in portions of the river north of the Abernethy Bridge that are being considered for siting the outfall diffuser.

3. Comparison of historical bathymetric data shows the alignment of the thalweg (deepest river channel) has moved little in this area since 1946, the time of the earliest bathymetric survey located.

4. Comparison of cross-sections cut along two alignments (A and B) at the upstream and downstream edges of the suitable diffuser region (refer to Figure 1) showed essentially little to no change in bed elevation since 1999 for the upstream alignment and a change of less than 2 feet since 1995 for the downstream alignment, which is considered to be within the accuracy of the data.

5. Sediment samples collected in June 2019 show that the riverbed is composed of medium to very coarse gravel (e.g., cobbles) with D50 grain sizes on the order of 1 to 2 inches or greater. Geotechnical borings collected for the Abernethy Bridge Widening Project indicates a 10- to 30-foot-thick layer of gravel alluvium across much of the river bed near the central river channel under the Abernethy Bridge.

6. It is likely that most of the finer grained material is deposited upstream of Willamette Falls. Material that remains in suspension and is transported over the falls or through the power plant intakes at the falls will likely move through the site as suspended load.

7. Model results indicate that hydraulic conditions during the 10-year return period event or less are unlikely to mobilize the D50 grain size of the river bed material along the length of the river portion of the outfall along Alignment A. The bed mobilization potential is greater downstream from Alignment B, but these river flows would still be unlikely to mobilize sediment with grain sizes greater than about 1.25 inches diameter.

8. The mobility potential of the river bed increases with distance downstream of the bridge, with a peak approximately 1,500 feet downstream of the bridge where the river cross-section narrows and water depths shallow due to a sill. Comparison of historical bathymetric data, however, indicates this increased bed mobility in the narrow area has not resulted in significant changes in bed elevation. Based on vertical and lateral changes in the thalweg, the area that has seen the least change is in the large pool bedform located between about 1,000 and 1,500 feet downstream of the bridge and upstream (south) of Alignment B.

9. Because of the gradient of increasing mobility potential with distance downstream from the preferred diffuser region, no gravel burial of the outfall diffuser would be predicted to occur during storms that mobilize sediments. Because bed mobility potential increases with distance downstream, any sediment transported into the diffuser region from upstream would be expected to be carried through the outfall area.

10. Bedforms, such as ripples or dunes, were not observed and would not be expected in the diffuser region. No significant bedforms were observed in the riverbed data, and would not be expected for a river with a gravel bed.

The results of the Willamette River bedform analysis show that the downstream diffuser region (shown in Figure 1) has riverbed stability suitable for diffuser sites and outfall routes. This region is the focus for diffuser site development and screening in this evaluation.

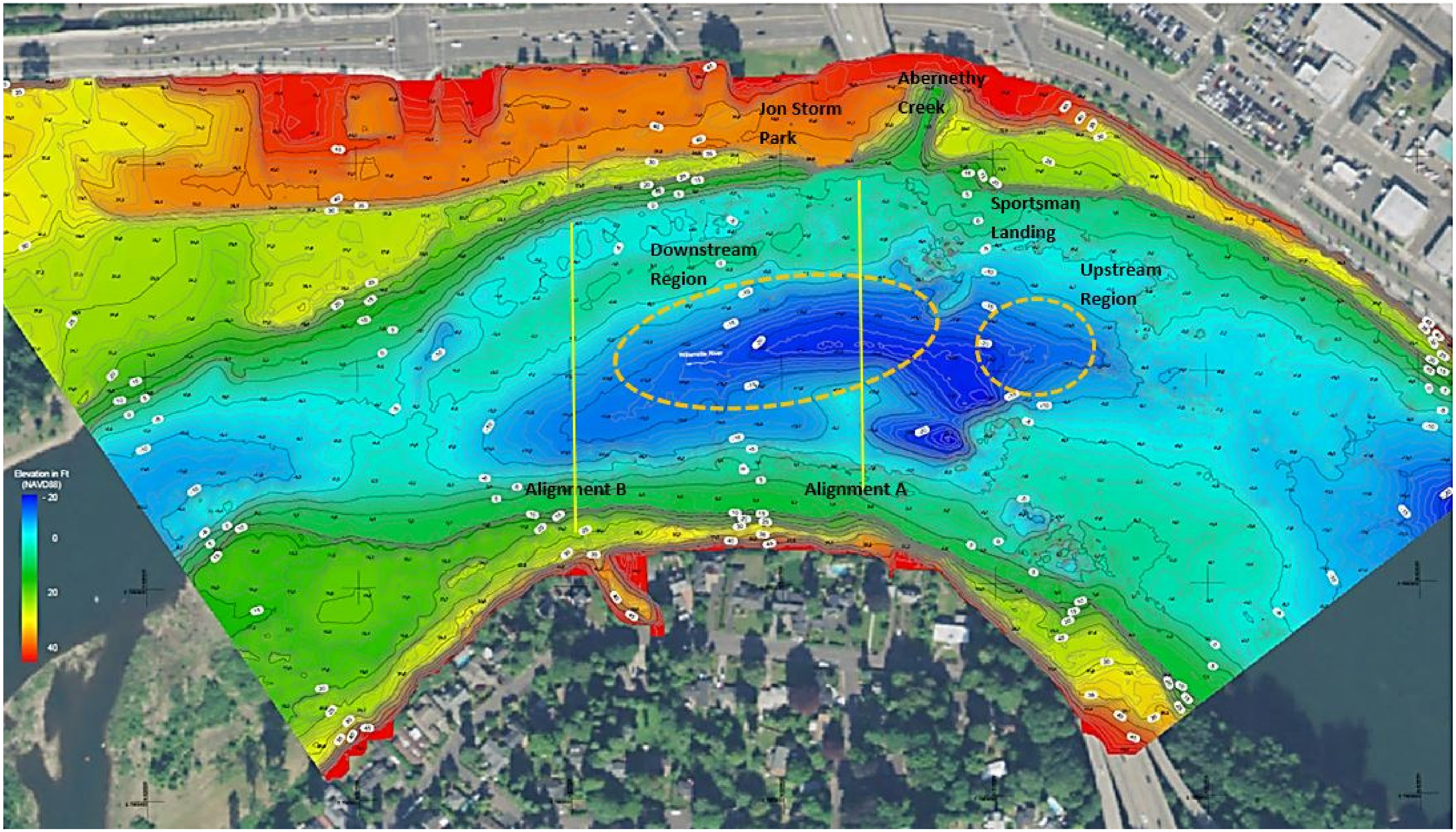

Figure 1. June 2018 Bathymetric Chart and Shoreline Topography with Identified Potential Diffuser Regions in River and Other Features

3. Diffuser Configurations and Preliminary Modeling

3.1 Diffuser Configurations Development

Diffuser siting and river outfall route evaluation criteria were developed to use in screening and identifying suitable Willamette River sites and routes. The region of the river channel with sufficient water depths to accommodate a diffuser is limited, as shown in Figure 1. Therefore, the diffuser design configuration—number, spacing, and size—of diffuser risers and ports is critical to maximizing the dilution performance for the new diffuser. The length of the new diffuser will be limited by available water depths and riverbed geometry. If the new diffuser is assumed to be installed below -15 feet elevation (North American Vertical Datum of 1988 [NAVD88]) to allow for adequate dilution performance, then the available space will require limiting the diffuser length to approximately 150 to 160 feet.

In addition, the Oregon Department of Environmental Quality (DEQ) *Regulatory Mixing Zones Internal Management Directive* (IMD) includes guidance objectives to limit mixing zone boundaries to 25 percent of the river cross-section at low river stage. The Willamette River in the diffuser region under evaluation in this study is approximately 700 feet wide at low river stage, which would potentially limit the width of the mixing zone boundary for a new diffuser to 175 feet. However, to accommodate the existing discharges of the Oak Lodge and Tryon Creek wastewater treatment plants, which are located on similar portions of the Willamette River, DEQ relaxed the IMD mixing zone boundary guidance objectives.

To establish preliminary outfall diffuser configuration for dilution modeling, the first step was to develop outfall pipe and diffuser riser sizes based on peak hour buildout effluent flow conditions (101 mgd) for the new outfall. Table 2 provides a summary of the step-wise evaluation of outfall and riser pipe selections for this preliminary evaluation. In the upper portion of Table 2, three outfall pipe sizes are compared, and the 84-inch-diameter pipe provides the probable best velocities and lowest head loss as a result. The lower portion of Table 2 shows a comparison of ranges of numbers of risers for 18-inch and 20-inch risers. screening applying peak hour buildout effluent flow identified a 20-inch riser as the logical selection to yield the lowest head loss for the outfall pipe size, effluent flows, and number of risers.

Table 2 includes riser pipe velocities, total riser area, ratio of riser area to pipe area, riser spacings, and diffuser lengths for these scenarios. The table includes peak hour buildout effluent flow (101 mgd) and the estimated peak hour flow in 2040 (60 mgd) to evaluate both stages. The table shows riser velocities equivalent to the outfall pipe velocity at 101 mgd flow for 18-, 19- or 20, 20-inch risers—indicating minimal head loss. This table also shows that it could be feasible to operate only 9 ports (every other port) under 60 mgd effluent flows and achieve equivalent riser velocities and head loss.

Table 2. Tri-City Outfall Risers and Ports Concepts Evaluation

No. Risers	Diffuser Pipe Size (inches)	Diffuser Pipe Area (ft^{2})	Size Diffuser Risers	Effluent Flow (mgd)	Effluent Flow per Riser (gpm)	Riser Velocity (fps)	Riser Diameter (inches)	Total Diffuser Riser Area (ft^2)	Ratio Riser Area/ Diffuser Pipe Area	Riser Spacing (ft)	Diffuser Length (ft)
16	84	38.5	20"	101.0	4384	4.5	20.0	34.9	0.91	10	150.0
15	84	38.5	20"	101.0	4676	4.8	20.0	32.7	0.85	10	140.0
14	84	38.5	20"	101.0	5010	5.1	20.0	30.5	0.79	11.5	149.5
14	84	38.5	20"	101.0	5010	5.1	20.0	30.5	0.79	12	156.0
13	84	38.5	20"	101.0	5395	5.5	20.0	28.4	0.74	12.5	150.0
20	84	38.5	18"	101.0	3507	4.4	18.0	35.3	0.92	8	152.0
20	84	38.5	20"	101.0	3507	3.6	20.0	43.6	1.13	8.5	161.5
19	84	38.5	18"	101.0	3692	4.7	18.0	33.6	0.87	8.5	153.0
18	84	38.5	20"	101.0	3897	4.0	20.0	39.3	1.02	9	153.0
19	84	38.5	20"	60.0	2193	2.2	20.0	41.5	1.08	8.5	153.0
18	84	38.5	20"	60.0	2315	2.4	20.0	39.3	1.02	9	153.0
10	84	38.5	20"	60.0	4167	4.3	20.0	21.8	0.57	17	153.0
9	84	38.5	20"	60.0	4630	4.7	20.0	19.6	0.51	18	144.0

fps = feet per second; ft = feet; ft^2 = square feet; gpm = gallons per minute; mgd = million gallons per day.

3.2 Preliminary Diffuser Modeling

Based on the preliminary concept evaluation described above and applying Willamette River stage and flow data and the river bathymetry in the *Willamette River Site Characteristics Technical Memorandum – Task 2.2.4* (Jacobs, February 2020), an 18-riser/port configuration (153-foot-long diffuser) was selected to apply in the preliminary dilution modeling. It is possible that a 20 port diffuser (162-foot-long) could be applied, but it would require placing diffuser ports more inshore at approximately 10 to 12 feet of water depth – which reduces the dilutions from the shallower ports. The Visual Plumes dilution model UM3 was used for these preliminary modeling runs. Sensitivity model runs were first conducted to determine the optimal diffuser port horizontal angle (45 degrees off diffuser alignment) and vertical angle (45 degree above bed). Tables 3 and 4 summarize the dilution results for the 18-port diffuser with 2040 effluent and buildout effluent flows, respectively. These tables include dilution factors at the acute and chronic mixing zone boundaries (assumed 30 feet and 300 feet, respectively), the maximum river flow-based dilution (complete mix with river), and the plausible flow-based dilution based on diffuser length and predicted plume width. Note that in all cases, the model-predicted dilution factors are less than the maximum or plausible flow-based dilutions—showing that the model is not over-predicting dilutions.

The model-predicted dilutions for 2040 effluent flows (Table 3) are substantial and they represent approximately 75 percent of the plausible maximum dilution based on diffuser and plume cross-section in the river flow. The acute dilution factor (27) is a flux-average dilution and it would be converted to a centerline dilution of 19 by DEQ guidance. The model-predicted dilutions for buildout effluent flows (Table 4) are lower in proportion to the increase effluent flows, and they represent approximately 75 to 80 percent of the plausible maximum dilution based on the diffuser and plume cross-section in the river flow. The acute dilution factor (21) is a flux-average dilution and it would be converted to a centerline dilution of 15 by DEQ guidance.

Table 3. Outfall Dilution Modeling Results for 18-port Diffuser with 20-inch Elastomeric Check Valve Ports – 2040 Effluent Flows

No. Ports	Effluent Flow (mgd)	Port Velocity (fps)	2040 Flow Conditions	Acute DF at ZID (30 feet) under 7Q10 river flow	Chronic DF at RMZ (300 feet) under 7Q10 river flow	Maximum River Flow-based Dilution at 7Q10	Maximum River Flow-based Dilution at 30Q5	Plausible Diffuser X-section Flow-based Dilution at 7Q10	Plausible Diffuser X-section Flow-based Dilution at 30Q5	RMZ-IMD Model Conditions
18	45.0	5.0	MDWWF-2040	**27**	--	84	102	45	61	Acute DFs
18	27.0	3.8	MMWWF-2040	--	**57**	140	169	75	101	Chronic DFs
18	23.8	3.6	MDDWF-2040	**33**	--	159	192	85	114	Acute DFs
18	18.0	3.1	MMDWF-2040	--	**83**	210	254	112	151	Chronic DFs
18	13.0	2.6	Annual DWF-2040	--	**112**	291	352	155	210	HHC DFs

7Q10 = lowest 7-day average flow that occurs (on average) once every 10 years; 30Q5 = lowest 30-day average flow that occurs (on average) every 5 years; DF = dilution factor; DWF = dry weather flow; fps = feet per second; HHC = human health criteria; IMD = Internal Management Directive; MDWWF = maximum day wet weather flow; mgd = million gallons per day; MMWWF = maximum month wet weather flow; RMZ = regulatory mixing zone; ZID = zone of immediate dilution.

Table 4. Outfall Dilution Modeling Results for 18-port Diffuser with 20-inch Elastomeric Check Valve Ports – Buildout Effluent Flows

No. Ports	Effluent Flow (mgd)	Port Velocity (fps)	Buildout Flow Conditions	Acute DF at ZID (30 feet) under 7Q10 river flow	Chronic DF at RMZ (300 feet) under 7Q10 river flow	Maximum River Flow-based Dilution at 7Q10	Maximum River Flow-based Dilution at 30Q5	Plausible Diffuser X-section Flow-based Dilution at 7Q10	Plausible Diffuser X-section Flow-based Dilution at 30Q5	RMZ-IMD Model Conditions
18	84.0	7.2	MDWWF-2040	21	--	45	54	24	32	Acute DFs
18	56.0	5.7	MMWWF-2040	--	31	68	82	36	49	Chronic DFs
18	30.5	4.1	MDDWF-2040	31	--	124	150	66	89	Acute DFs

18	23.0	3.5	MMDWF-2040	--	67	164	199	88	118	Chronic DFs
18	18.0	3.1	Annual DWF-2040	--	83	210	254	112	151	HHC DFs

7Q10 = lowest 7-day average flow that occurs (on average) once every 10 years; 30Q5 = lowest 30-day average flow that occurs (on average) every 5 years; DF = dilution factor; DWF = dry weather flow; fps = feet per second; HHC = human health criteria; IMD = Internal Management Directive; MDWWF = maximum day wet weather flow; mgd = million gallons per day; MMWWF = maximum month wet weather flow; RMZ = regulatory mixing zone; ZID = zone of immediate dilution.

Based on these results, an 18-riser/port configuration with 20-inch diameter risers (153-foot-long diffuser) is considered a reliable diffuser solution for the Tri City WRRF Willamette River Outfall Project given the river site constraints of depth and space for a diffuser.

Table 5 provides a screening-level evaluation of the dilutions required for the Tri-City WRRF discharge of effluent ammonia—the key effluent constituent for diffuser design. This preliminary evaluation shows that the Tri-City WRRF discharge of effluent ammonia requires dilutions of 5 (dry season) to 2 (wet season) to comply with the acute ammonia criteria (at the acute zone boundary), and the preceding dilution modeling of an 18-port diffuser shows centerline dilutions of 19 (2040) to 15 (buildout) that exceed these required dilutions. This preliminary evaluation shows effluent ammonia requires dilutions of 29 (dry season) to 14 (wet season) to comply with chronic 4-day ammonia criteria (at the chronic mixing zone boundary), and the preceding dilution modeling of an 18-port diffuser shows dilutions of 83 (2040) to 67 (buildout) that exceed these required dilutions. This evaluation also shows effluent ammonia requires dilutions of 50 (dry season) to 32 (wet season) to comply with chronic 30-day ammonia criteria (at the chronic mixing zone boundary). The preceding dilution modeling of an 18-port diffuser did not include the 30Q5 river flow condition (applied to 30-day criteria condition) only the 7Q10 river flow condition (applied to 4-day criteria condition). However, dilutions of 83 (2040) to 67 (buildout) can be assumed for this screening-level evaluation and these dilutions under lower river flow conditions exceed these required dilutions for the 30-day ammonia criteria. Additional dilution modeling and discharge compliance assessments will be developed as part of the outfall diffuser conceptual design development.

Table 5. Evaluation of Discharge Compliance with DEQ Ammonia Water Quality Criteria and Preliminary Definition of Target Design Dilutions for the Tri City WRRF Discharge of Ammonia to Willamette River

Parameter	Water Quality Criteria [a]		No. of Samples	Maximum Effluent Concentration (mg TAN/L) [d]	Multiplying Factor (99% C.I. and 95% Prob.) [e]	Background River Concentration (90th %) (mg N/L)	Minimum Dilution Needed to Meet Acute WQ Criteria at ZID	Minimum Dilution Needed to Meet Chronic Criteria at RMZ
	Acute Criteria (mg/L) [b]	Chronic Criteria (mg/L) [c]						
Dry Season (May–Oct)	7.3	1.2 (4-day) 0.7 (30-day)	310	34.7	1.0	0.03	**5**	**29** (4-day) **50** (30-day)
Wet Season (Nov–Apr)	15	2.5 (4-day) 1.1 (30-day)	365	35.0	1.0	0.03	**2**	**14** (4-day) **32** (30-day)

[a] Freshwater acute and chronic water quality criteria from U.S. Environmental Protection Agency (EPA) August 2013 Revised Freshwater Ammonia Criteria, as implemented by DEQ in 2015. Acute and chronic criteria based on dry season dry season maximum river temperature of 21.1 degrees Celsius (°C) and pH of 7.6, and wet season maximum river temperature of 12°C and pH of 7.4.

[b] The freshwater acute criterion is 1-hour average concentration not to be exceeded more than once every 3 years on average.

[c] The freshwater chronic criterion is 4-day average concentration not to be exceeded more than once every 3 years on average.

[d] Ammonia based on effluent ammonia concentrations for Tri City WRRF (January 2015–April 2019).

[e] The reasonable potential multiplying factor assumes a coefficient of variation of 0.6, based on guidance in Table 3-2 (p. 57) in the Technical Support Document for Water Quality-Based Toxics Control (EPA, 1991).

mg/L = milligrams per liter; RMZ = regulatory mixing zone; WQ = water quality; ZID = zone of immediate dilution.

4. Development and Evaluation of Diffuser Site/Outfall Route Alternatives

4.1 Development of Alternatives

Three diffuser site/outfall route alternatives from the shore to the diffuser were developed for evaluation. This was done by identifying viable diffuser sites and developing routes to them. The diffuser site/outfall route alternative locations are shown in Figure 2. The diffuser configurations identified for Alternatives 1 and 2 are approximately 153-foot diffusers allowing for 18 ports at 9 foot spacing to be located between -15 and -22 feet NAVD88. The diffuser identified for Alternative 3 is an approximately 162-foot diffuser allowing for either 20 ports at 8.5 foot spacing or 19 ports at 9-foot spacing to be located between -12 and -21 feet NAVD88.

Table 6 provides a review of these three diffuser site/outfall route alternatives in comparison to the screening criteria listed in Table 1 of this TM.

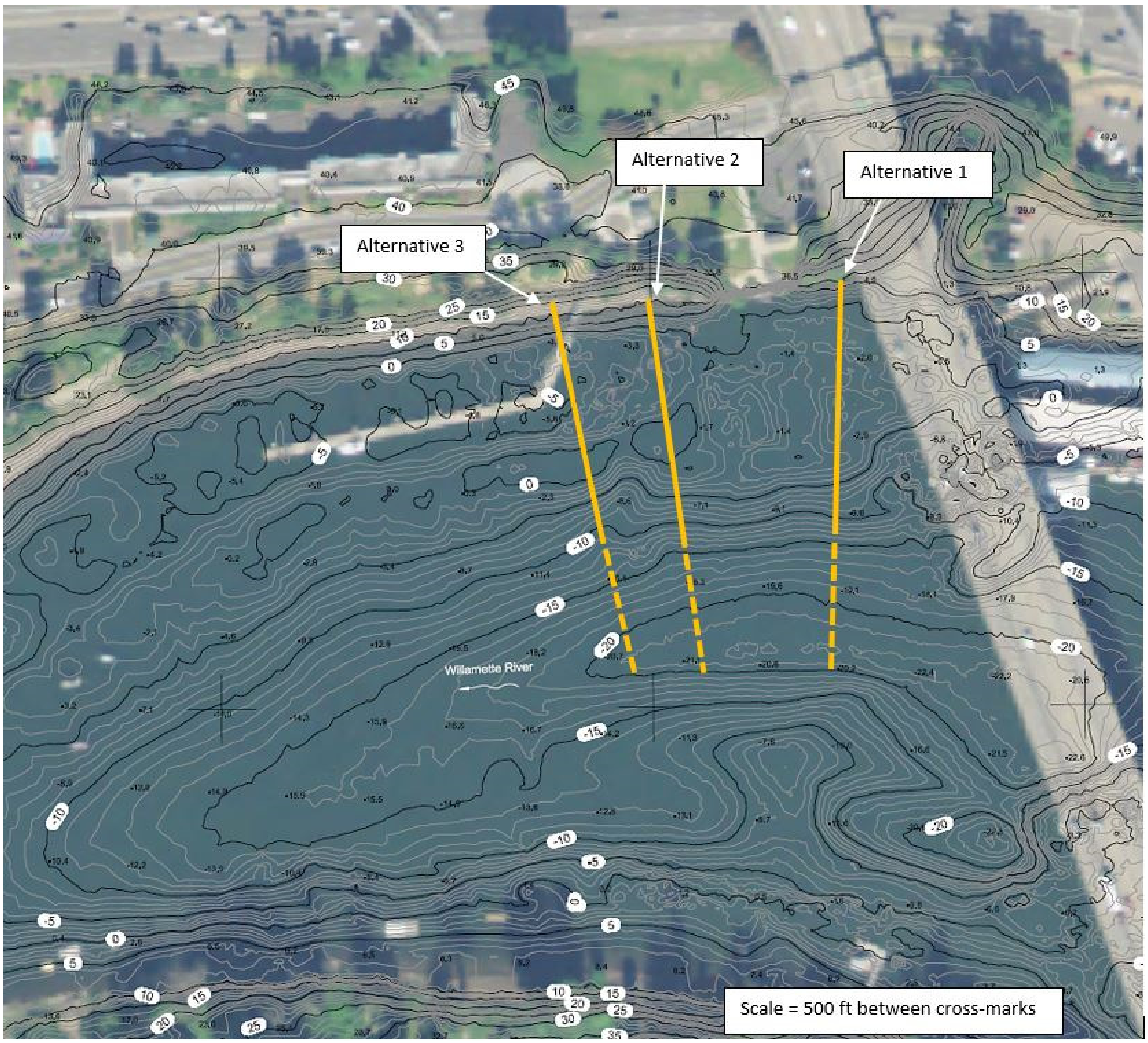

Figure 2. Locations of Proposed Diffuser Site/Outfall Route Alternatives in the Willamette River

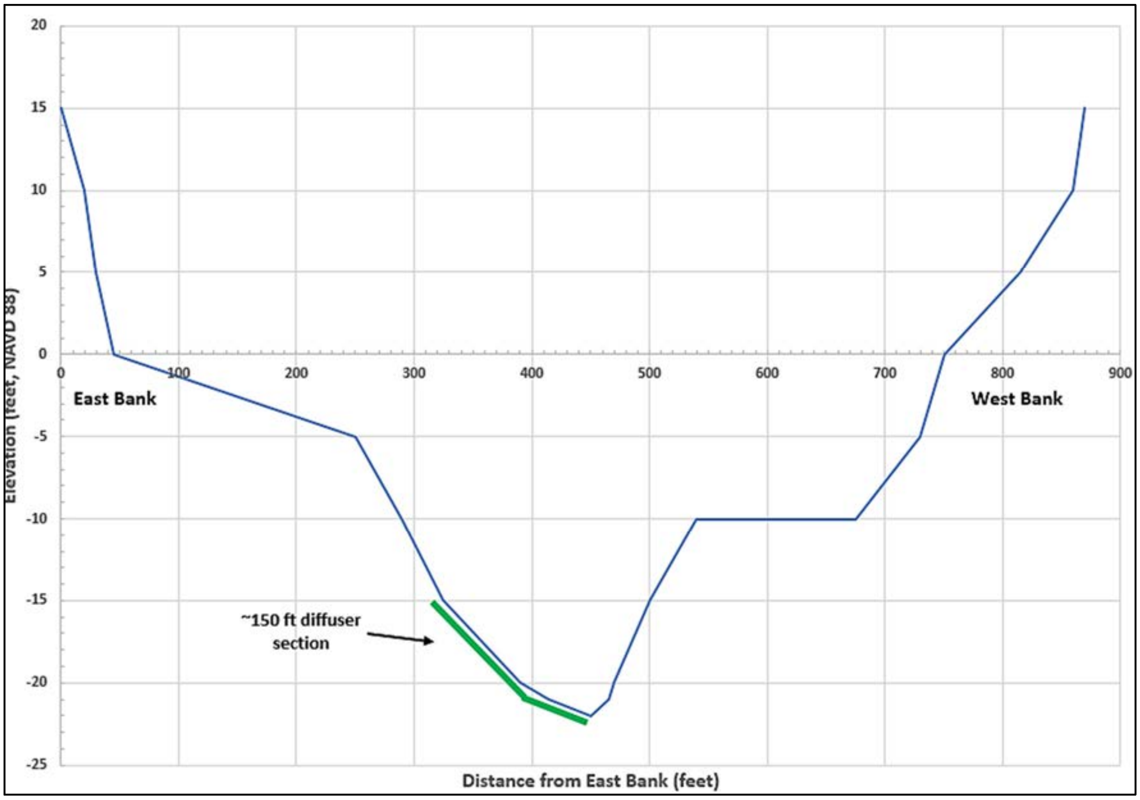

Figure 3. Cross-section of the Willamette River along Outfall Route of Alternative 1 Showing the Diffuser Site

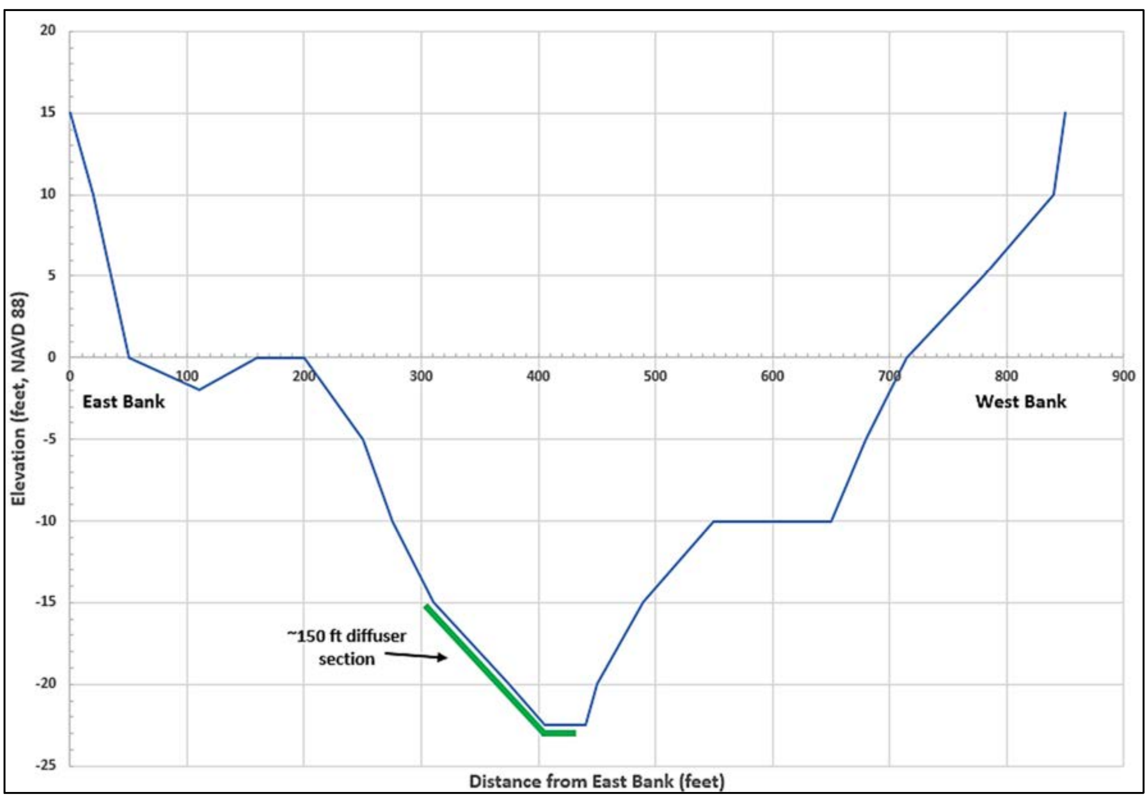

Figure 4. Cross-section of the Willamette River along Outfall Route of Alternative 2 Showing the Diffuser Site

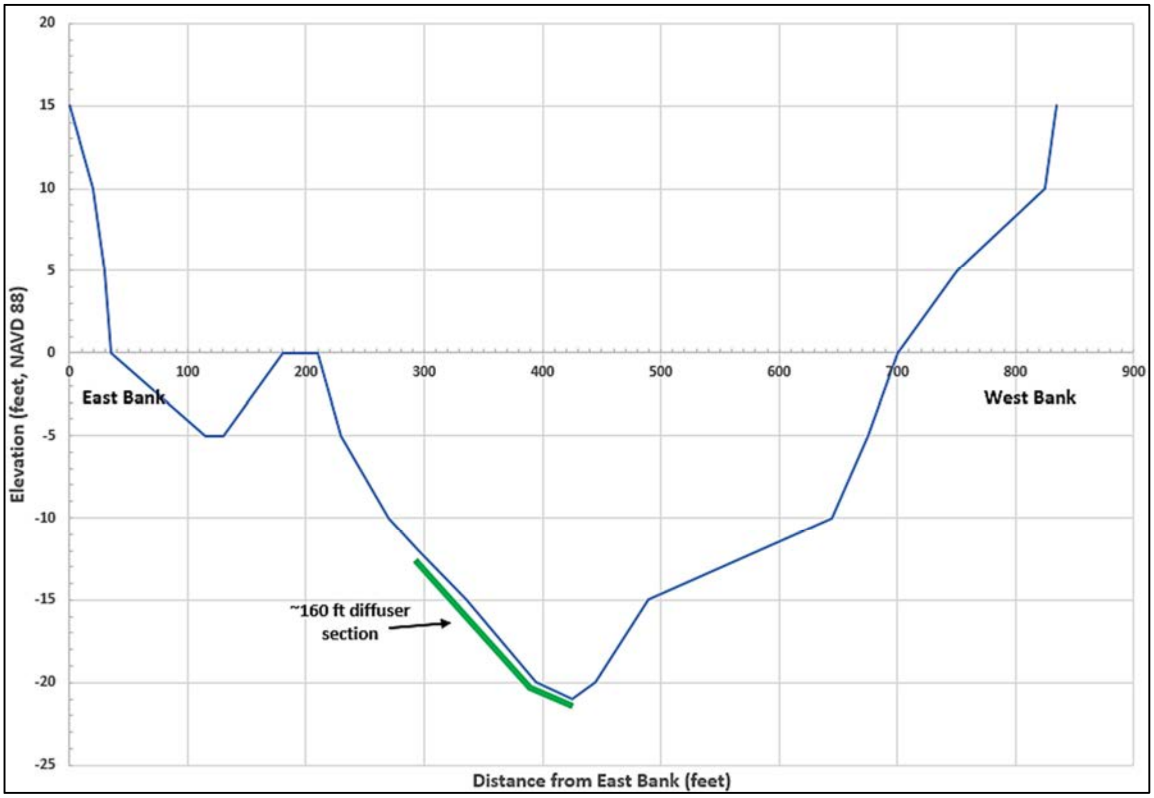

Figure 5. Cross-section of the Willamette River along Outfall Route of Alternative 3 Showing the Diffuser Site

4.2 Evaluation of Diffuser Site/Outfall Route Alternatives

The selected alternative will depend on non-engineering factors. Alternatives 2 and 3 are both considered less complex to design and construct than Alternative 1 due to the bridge expansion construction and proximity of Abernethy Creek. Alternative 3 is shallower and would likely require a 162-foot diffuser to achieve dilutions equal to the other sites, which would add cost, but not be a significant performance issue. Alternatives 2 and 3 could proceed on a WES schedule, provided it is approved by Oregon City voters. Alternative 1 will require continuous coordination with ODOT and potential oversight of any trestle construction over the installed outfall, and construction timing with ODOT could be an obstacle to the WES schedule.

The timeline for Alternative 1 depends on the construction funding and schedule for the Abernethy Bridge. There are three potential scenarios for the bridge construction: (1) it is funded and built in the near future; (2) the bridge improvements are removed from ODOT's program; and (3) the project remains on ODOT's program but is indefinitely delayed. Scenarios 2 and 3 leave Alternative 1 with no clear timeline and this route will also require extensive negotiations with ODOT to define the various risks and responsibilities.

The recommended alternative will be confirmed following discussions with ODOT, a workshop with WES, and further diffuser design analyses.

Table 6a Comparison of Diffuser Site Alternatives to Screening Criteria

Subject	Screening Criteria	Application of Criteria	Alternative 1	Alternative 2	Alternative 3
Diffuser Site Screening	Location in river cross-section	Avoid potential use conflicts	Diffuser located in center-east of river thalweg; approximately 100 ft downstream of the Abernethy Bridge pier	Diffuser located in center-east of river thalweg	Diffuser located in center-east of river thalweg
	Water depth range at site	Effectiveness of diffuser dilution performance	Diffuser at -15 to -22 ft (NAVD88)	Diffuser at -15 to -22 ft (NAVD88)	Diffuser at -12 to -21 ft (NAVD88)
	Geometry to install diffuser	Effectiveness and constructability	Diffuser on moderately steep slope into river thalweg	Diffuser on moderately steep slope into river thalweg	Diffuser on moderately steep slope into river thalweg
	Riverbed materials	Structure stability and avoid burial or scour	Stable riverbed materials along diffuser route	Stable riverbed materials along diffuser route	Stable riverbed materials along diffuser route
	River current velocities	Effectiveness of diffuser dilution performance	Diffuser site exposed to strongest river currents	Diffuser site exposed to strongest river currents	Diffuser site exposed to strongest river currents
	Absence of wood debris and piles	Safe site to avoid damage and maintenance	No accumulations of wood debris observed on bathymetry chart and no piles	No accumulations of wood debris observed on bathymetry chart; breakwater piles to route through	No accumulations of wood debris observed on bathymetry chart; floating dock piles and ramp to route pipe through
	Dilution performance at critical flows	Dilutions to minimize/avoid effluent limits	Diffuser site allows 150- to 160-ft diffuser for dilutions	Diffuser site allows 150- to 160-ft diffuser for dilutions	Diffuser site allows 150- to 160-ft diffuser for dilutions, but shallower site for diffuser

Table 6b. Comparison of Outfall Route Alternative to Screening Criteria

Subject	Screening Criteria	Application of Criteria	Alternative 1	Alternative 2	Alternative 3
Outfall Route Screening	Proximity to diffuser site from shore	Construction cost effectiveness	Approximately 300- to 150-ft diffuser	Approximately 290- to 150-ft diffuser	Approximately 275- to 160-ft diffuser
	In-river structures or obstacles	Avoid construction conflicts and cost additions	Outfall construction route and timing overlaps with Abernethy Bridge expansion and Jon Storm Park, with route through region of construction trestles – adding risk of damage	Outfall construction route through breakwater piles – adding costs for coordination with park and restoration	Outfall construction route on edge of Jon Storm Park and crosses under floating dock ramp - adding cost for coordination with park and restoration
	Shoreline structures and uses	Avoid construction conflicts and cost additions	Outfall construction route on shore requires coordination with Abernethy Bridge expansion project – possible impacts to schedule and design requirements; steep unstable shore slope and proximity to Abernethy Creek add complexity	Outfall construction route through Jon Storm Park shoreline and breakwater piles – adding costs for coordination with park and restoration	Outfall construction route on edge of Jon Storm Park and crosses under floating dock ramp - adding cost for coordination with park and restoration
	Riverbed materials	Structure stability and constructability	Stable riverbed materials along outfall route	Stable riverbed materials along outfall route	Stable riverbed materials along outfall route