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Bell Bay Pulp Mill

Outfall Near-Field Modelling - Addendum

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PROJECT 301010-00512 - BELL BAY PULP MILL

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CONTENTS

1. PURPOSE

The near field CFD modeling was undertaken during the developmental stages of the far field modeling and the purpose of this Addendum Report is to confirm diffuser performance and coupling parameters for the preferred diffuser length of 250 m.

2. PLUME CLOUD ESTIMATION

The plume cloud parameters (*Section 7.1.4 in the main repor*t) represent a schematised box containing a major portion of the terminal plume mass at the surface. The JETLAG model identifies the plume radius at a preset cutoff concentration of 0.036 (*Section 7.2 in the main repor*t), and a similar concentration was used as a cutoff in the CFD results to characterize the dimensions of the box. To ensure conservation of mass, the effective dilution of the effluent in the plume cloud box was then determined by apportioning the mass of effluent discharged over a 10 minute interval to the volume of the box.

3. PROPOSED DESIGN

The original modeling was undertaken for 200, 300, 400 & 500m diffuser lengths under a variety of cross-flow conditions. As an outcome, one-way near-field to far-field model coupling relationships were established for each diffuser length based on a cross-flow velocity of 0.018 m/s being a representative measure of low cross-flow periods when initial dilution is minimized (*Section 8.2 in the main repor*t).

Initial far-field modeling indicated that a 250m long diffuser would likely be sufficient for far-field dilution requirements to be met. The provision of one-way coupling parameters for a 250m diffuser necessitated extrapolation from the parameter values for the 300, 400 & 500m diffuser runs, since the 200m diffuser was configured with larger 150mm Duckbill valves and had a jet velocity that was not consistent with the other diffuser lengths. This extrapolated plume cloud height of 9.9m was used in the confirmation far-field modeling (*Table 8.1 in the main repor*t), and was thought to be conservative.

3.1 Additional Modelling

To confirm this position, two additional model runs were undertaken with the near-field CFD model (*setup as per Section 7.1.2 in the main repor*t)) for a 250m diffuser with 100mm Duckbill valves as follows:

Diffuser length	250 m
Diffuser ports	51 x 100mm Duckbill valves @ 5m C-C
Port discharge velocity	4.5 m/s
Port flow	14.52 l/s (64 Ml/day total)
Ambient density	1024 kg/cu.m
Uniform cross-flow	0.018 m/s
Port orientation	Option 1 - Vertical
	Option 2 - Horizontal (with direction of cross-flow)

In the case of the vertical port (*Option 1*), the increased jet velocity with respect to the 300m diffuser generates greater mixing and dilution, to an extent that exceeds the value linearly extrapolated from the 300, 400 & 500m diffuser data, **Table 3-1**. The additional momentum leads to wider spreading of the plume cloud across the surface and hence the increased initial dilution. The increased momentum will also ensure that the plume breaks through to the surface under potential stratified conditions, (*Section 5.5 in the main repor*t).

In the case of the horizontal port (*Option 2*), the increased trajectory length of the plume with respect to the vertical port generates further mixing and dilution, **Table 3-1**. It should also be noted that the potential for the Coanda effect, whereby the plume is attracted to, and attaches itself to the bed for some distance did not occur in the model run for the horizontal port.

Table 3-1 Raw model results, 250m diffuser, 0.018m/s cross-flow

Case	Plume Width (m)	Plume Height (m)	Plume Offset (m)	Initial Dilution
Extrapolated	54	9.2	9	279
Vertical port model	70	9.0	9	363
Horizontal port model	52	17.0	21	505

When translated to one-way coupling parameters for the 50m horizontal grid of the far-field model, the degree of conservatism inherent in the previously extrapolated values is apparent, **Table 3-2**.

Table 3-2 One-way coupling parameters adjusted for the 50m far-field grid - 250m diffuser

Case	Plume Width (m)	Plume Height (m)	Plume Offset (m)	Initial Dilution
Extrapolated	50	9.9	0	280
Vertical port model	50	12.7	0	356
Horizontal port model	50	17.6	0	495

3.2 Proposed Diffuser Design Parameters

As a result of this additional near-field confirmation modeling, it is clear that the far-field confirmation modeling with a plume cloud height of 9.9m should be considered as an upper bound estimate of potential far-field effluent concentrations.

In consideration of these additional near-field confirmation model runs, the proposed diffuser design would have the following parameters:

Parameter	Value
Diffuser length	250 m
Diffuser pipe diameter	800 to 1000 mm
Diffuser ports	100mm Tideflex Duckbill valves
Port spacing	5m C-C
Port orientation	Option 1: Vertical, top centre of pipe
	Option 2: Horizontal, from short riser, top centre of pipe

3.2.1 Selection of Port Geometry

In addition to the vertical and horizontal ports assessed with this additional modeling, consideration should be given to the T-bar riser configuration with two opposing horizontal reports. Previous modeling (*Section 6.2.1 in the main report*), indicated that such a configuration provided improved initial dilution under stagnant conditions because of the recirculation current generated by the interaction between the two plumes, leading to an increased vertical mixing depth. This phenomenon is lost under moderate crossflow conditions when the T-bar configuration performs similarly to a vertical port.

The vertical port is recommended for its simplicity and its adequate initial dilution under low ambient crossflow conditions, however the increased dilution obtained under these conditions with a two port T-bar riser could be employed as an extra precautionary measaure.