Tutorial 3 – An example outfall in the Port Shelter

After going through Tutorial 1 and 2, it is assumed users have already gained familiarity to using the VISJET 3 interface, and how to access the information provided. In this tutorial, we will illustrate how the VISJET 3 can be used in assessing the impact of an outfall, which is often useful for choosing an outfall location and detailed outfall design.

Problem definition
In order to meet the projected flow and loads generated from future development and planned extension of the sewerage collection system of Sai Kung, it is proposed that a new outfall should be constructed. The projected Average Dry Weather Flow (ADWF) is 22,000 m^3/d, and the peaking factor is 3.1, giving 68,200 m^3/d as the design flow of the outfall. The wet weather flow is about 30% larger and is given by 28,600 m^3/d. The proposed outfall has a length of 90 m at a water depth of 15 m. 18 ports are proposed to be installed at the diffuser, with port diameter of 0.15 m.

The proposed standards of the partially treated wastewater from the treatment plant are:

	95 percentile	Maximum
BOD_5 (mg/l)	20	40
Total suspended solid (mg/l)	30	60
Unionized ammonia (mg/l)	-	0.9 (assumed)
E. coli (counts/100 ml)	1500	-

The measure ambient marine water quality and the target water quality objectives are given as follows:

Parameter	Measured ambient level	Water quality objectives
Temperature (^{o}C)	23.6 (16.3 – 28.4)	Not cause daily temperature range to change more than 2°C
Salinity (psu)	31.4 (28.3 – 33.1)	Not cause natural salinity level to change more than 10 %
SS(mg/l)	2.1 (0.7 – 4.2)	Not to cause natural ambient level to be raised by 30%
BOD_5 (mg/l)	0.8 (0.3 – 1.9)	Not to exceed 5 mg/l for inland waters
Unionized Ammonia (mg/l)	0.001 (<0.001- 0.010)	Not more than annual average of 0.021 mg/l
E. coli	1	Not exceed 610/100ml at fish culture

(count/100ml)	(1-3)	subzones Not exceed 180/100 ml at bathing beach subzones

The ambient stratification of the dry weather and the wet weather is given as follows:

Dry Weather:

Water depth (m)	Temperature (^{o}C)	Salinity (ppt)
0	23.5	33.2
7.5	23.2	33.2
15	23.1	33.2

Wet Weather:

Water depth (m)	Temperature (^{o}C)	Salinity (ppt)
0	30.9	28.6
7.5	28.1	29.6
15	26.4	31.6

You are asked to decide a suitable outfall location to ensure the effluent discharge will meet the water quality standards. As a quick estimation, you should ensure the near field mixing zone will not affect the nearby sensitive receivers (Fish culture zones and beaches) to a standard as stated in the above tables.

Examples for both the dry weather and wet weather are done for you, which are roughly the designed outfall parameters.

Scenario 1 – Dry weather

Dry weather flow = 22,000 m^3/d = 0.255 m^3/s

Outfall location:
EASTING (X) : 846523.9
NORTHING (Y): 825846.5
Outfall depth (Z): 15 m

Outfall parameters:
Total Flow: 0.255 m^3/s
Temperature: 26 ^{o}C
Salinity: 1 ppt
Concentration: 1 relative unit
Length: 90 m
Diameter: 1 m

Distance: -
Orientation: -60°

Jet parameters:
Number of jets: 18
Diameter: 0.15 m
Vertical angle: 90°
Horizontal angle: 0°
Distance: 5.3 m (evenly distributed)

General Notes:
1. *Create firstly a scenario* in Port Shelter as instructed in tutorial 1,
choosing a desired file location path.

2. *Input ambient parameters*: Input the dry weather ambient parameters
given above as instructed in the previous tutorials. The current direction
is given as 30°. Current speed assumed to be 0.01 m/s.

3. *Choose the outfall location*:
(i) As an example, the coordinates of the outfall have been given to you.
(ii) enter 846523.9 in X and 825846.5 in Y in the position window.
(iii) enter the outfall depth 15 m in Z in the position window.

4. *Input outfall parameters*:
(i) highlight Outfall#01, enter the outfall parameters as given above.
(ii) The horizontal outfall orientation is given as -60°.

5. *Create jets at the diffuser*:
(i) Highlight Outfall#01, click the **"New Jet"** button.
(ii) Enter the given jet parameters.
(iii) Highlight Jet #01, click **"New Jet"** , the new jet (Jet $02) will
automatically be created with the parameters entered as Jet#01. Create Jet
#03 – Jet #18 in similar way.
(iv) Highlight Outfall#01, click the **"Evenly Distribute Jets"** button,
these jets will then be distributed evenly along the diffuser with spacing
calculated.

6. Check all the information entered, and run the model by clicking
"Start Near-Field VISJET simulation" at the   toolbar.

Mixing zone analysis

7. Observe the evolution and spread of the jet group. The mixing zone can be visualized. In this case, the mixing zone is small enough that nearby sensitive receivers are not affected. The remaining work is to ensure the effluent meets the water quality standards stated in the problem definition in the water quality control zone.

Calculation of water quality parameters at end of near field
8. Study the dilution of the jet group
(i) In this case, the jets are not interacting with each other (as can be visualized), the dilution attained can be treated as the dilution attained by each individual jet.
(ii) Open the **"SUSPEND FILE"** and obtain the surface dilution.
(iii) In this case the average dilution at the surface layer is S=99.29 at a level z=12.57 m above the discharge port.

9. Calculate the concentration of each quantity
(i) Note that for this time, different from tutorial 2, there is a different background concentration for each quantity.

10. Example calculations:

(i) BOD_5 –
Background: 0.8 mg/l
Standard: 5 mg/l
Effluent: 40 mg/l

BOD_5 after dilution (BOD_{5d})
$S=(40-0.8)/(BOD_{5d}-0.8) = 99.29$
$BOD_{5d} = 1.19$ mg/l < 5 mg/l (OK)

(ii) Suspended solid (SS) –
Background: 2.1 mg/l
Standard: $2.1(1+0.3) =$ 2.73 mg/l
Effluent: 60 mg/l

SS after dilution (SS_d)
$S=(60 – 2.1)/(SS_d – 2.1) = 99.29$
$SS_d = 2.68$ mg/l < 2.73 mg/l (OK but marginal)

(iii) Unionized Ammonia (UA)
Background: 0.001 mg/l
Standard: 0.021 mg/l
Effluent: 0.9 mg/l

UA after dilution (UA_d)

$S = (0.9 - 0.001)/(UA_d - 0.001) = 99.29$

$UA_d = 0.010$ mg/l < 0.021 mg/l (OK)

(iv) *E. coli* (EC)
Background: 1 counts/100 ml
Standard: 180 counts/100 ml
Effluent: 1500 counts/100ml

EC after dilution (EC_d)
$S = (1500 - 1)/(EC_d - 1) = 99.29$
$EC_d = 16$ counts/ 100 ml < 180 counts/100 ml (OK)

Summary:

	Effluent	Standard	After dilution	OK ?
BOD$_5$ (mg/l)	40	5	1.19	Yes
Total suspended solid (mg/l)	60	2.73	2.68	Yes
Unionized Ammonia (mg/l)	10	0.021	0.010	Yes
E. coli (counts/100 ml)	1500	180	16	Yes

11. Try out other current speed and outfall designs to study their effect on the mixing zone and dilution

Scenario 2 – Wet weather
12. This example is similar to Scenario 1 except the discharge and the ambient stratification is changed. Change the ambient parameters and outfall flow (Q=0.331 m^3/s) to the wet weather conditions as given above.

13. Simulate the discharge again by clicking **"Start Near-Field VISJET simulation"**. ᵂᴶ▶

14. Observe the jet group evolution and spread. Due to ambient stratification, jets are trapped under the water surface. The jets are not interacting at this current speed and spacing.

15. Obtain the dilution by viewing the **"SUSPEND FILE".** This time the dilution is found to be S=44.0 at a level of z=9.71 m above the discharge port.

Mixing zone analysis
16. The mixing zone is again small and should not affect the nearby sensitive receivers.

Calculation of water quality parameters at end of initial dilution zone

17. Similar to the calculation in the dry weather, the near field water quality for wet weather is tabulated:

	Effluent	Standard	After dilution	OK ?
BOD$_5$ (mg/l)	40	5	1.69	Yes
Total suspended solid (mg/l)	60	2.73	3.42	No
Unionized Nitrogen (mg/l)	0.9	0.021	0.021	Marginal
E. coli (counts/100 ml)	1500	180	35	Yes

18. Try out other current speed and outfall designs to study their effect on the mixing zone and dilution.