Attachment D

Additional details, not provided in SL Ross (2011), on the algorithms employed in the SLROSM spill model used in the simulations are provided in Tables 2.20 and 2.21. The modelling parameters provided in Table 2.15 of the report cited above were used in the oil property change relationships shown in tables 2.20 and 2.21.

Table 2.20   Comparison of Model Oil Fate and Behaviour Equations

Batch Spill	Above-Sea Blowout	Subsea Blowout
INITIAL SLICK CHARACTERISTICS		
a) Initial thickness of thick slick = 2cm	a) Volume mean diameter of oil spray droplets calculated using atomization equations of Deyson and Karian (1978) as described in S.L. Ross and Energetex (1985)	a) Volume mean diameter of oil droplets produced at wellhead calculated using atomization equations of Deyson and Karian (1978) as described in S.L. Ross and Energetex (1985)
b) Initial thick slick area = spill volume/2 cm	b) Atmospheric dispersion and settling of droplets estimated using Turner's (1970) equations	b) Initial width and thickness of slick downstream of blowout are calculated using subsea blowout plume equations of Fannelop and Sjoen (1980) as described in S.L. Ross (1982), using gas & oil flowrates, well depth and surface current
c) Initial thin slick area = 8 x thick area	c) Amount of evaporation of oil droplets in air circulated using modified evaporative exposure equation given in S.L. Ross and DMER (1988)	c) If the fresh oil's pour point exceeds the sea temperature, the slick consists as discrete droplets or "peas"
d) Initial thin volume = thin area x 1µm	d) Initial oil properties are calculated based on initial evaporation and desired sea temperature	d) Initial evaporation, emulsification and natural dispersion are back-calculated from the release point to the time required to reach the initial width based on a geometric mean thickness between the two locations
e) Oil properties corrected to desired sea temperature	e) If the oil's pour point exceeds the sea temperature, the oil does not form a slick on the sea surface but forms a series of discrete droplets or "peas"	e) The initial slicklet thickness is corrected to account for initial evaporation, emulsification, and natural dispersion

Batch Spill	Above-Sea Blowout	Subsea Blowout
	f) The initial width and thickness of the slick are calculated using a surface current, b) and c) above; a slicklet (of length 100s x surface current) is subsequently modeled	f) Initial oil properties area calculated based on initial evaporation, emulsification, and desired sea temperature

SPREADING

Batch Spill	Above-Sea Blowout	Subsea Blowout
Thick Slick Modified Mackay et al. (1980) equations, based on Fay gravity-viscous including emulsion viscosity; if oil's pour point exceeds sea temperature the thick slick spreading ceases: $\Delta A_{thick} = 2.2(1025 - \rho_o) \times 9.82 / (\rho_o\mu_o/10^3)^{1/2})^{2/3} (X_{thick})^{4/3} (A_{thick})^{1/3} \Delta t - (1 \times 10^{-6} \Delta_{thin}/X_{thick})$	Thick Slick Modified Fay "point source" surface tension-viscous equation (for lateral spreading only); include emulsion viscosity; if spreading coefficient falls below 0, thick slick spreading ceases: $\Delta W_{thick} = \frac{3}{4} (\theta)^{1/2}/(\Lambda_o\mu_o/10^3 t)^{1/2} \Delta t$	Thick Slick As per above-sea blowout
Thin Slick Modified Mackay et al. (1980) equations, based on Fay surface-tension viscous; include oil viscosity; if spreading coefficient falls below 0, thin spreading stops; think slick 'fed' by thick slick: $\Delta A_{thin} = 4.55 (\theta/(\rho_o\mu_o/10^3)^{1/2})^{1/3} \exp(-0.003/X_{thick})\Delta t$	Thin Slick As for thick slick, but using weathered oil properties, instead of emulsion properties	Thin Slick As per above-sea blowout

EVAPORATION

Uses modified evaporative exposure (Stiver and Mackay 1983) based on S.L. Ross and DMER 1988; includes internal mass transfer resistance if the oil's pour point exceeds ambient temperature by 15°C

Thick Slick
$\Delta F_v = (\Delta t/X_{thick}(HC/10^{-6} X_{thick} + (1/k))(\exp((6.3 - (10.3(T_0 + T_GF_v)/T_k))$

Where:
k= 0.0015 U0.78   (after Mackay et al. 1980)
C= 1 for slick
C= 6 for droplets of gelled oil
H= 0 if the oil's pour point is less than 15°C above the sea temperature
H= exp (6.3-10.3 $(T_0 + T_GF_v)/T_k$) if the oil's pour point exceeds sea temperatures by 15°C or more.

Thin Slick
Same as for thick slick, with C=1 and H=0 at all times. Initial fraction evaporated from the slick is 30%; maximum fraction evaporated from thin slick is 75%.

NATURAL DISPERSION
Thick Slick $\Delta F_{NDTHICK}= 2.78 \times 10^{-6} (U/8)^2 \Delta t/(\theta_{o/w}\mu_0(1025 - \Lambda_0))X_{THICK}$ If the oil's pour point exceeds the sea temperature by 15°C or more, or the oil is present as droplets, then $\Delta F_{NDTHICK}=0$
Thin Slick As above except using viscosity, density and thickness of thin slick; no pour point cut-off
EMULSIFICATION
Thick Slick $\Delta F_w = 2 \times 10^{-6}(U+1)^2 (1-1.33F_w)\Delta t$ After Zagorski & Mackay 1982. Oil does not begin to emulsify until it has reached a specified degree of evaporative exposure determined based on analysis of oil (Bobra 1989), if the oil is in the form of droplets it does not emulsify.
Thin Slick No emulsification of thin slick occurs.

Table 2.21 Expressions Used to Relate Weathering and Temperature to Oil Property Changes in S.L. Ross Model

Property	Units	Expression
Density	Kg/m^3	$\Lambda_o[1-C1 (T-T_o) (1+C2F)$
Emulsion density	Kg/m^3	$\Lambda_o (1-F_w) + 1025 F_w$
Viscosity	mPas (cp)	$\mu[\exp (C3\{1/T - 1T_o\}) \times \exp (C4F)]$
Emulsion Viscosity	mPas (cp)	$\mu[\exp (2.5F_w/\{1-0.65F_w\})]$
Aqueous solubility	g/m^3	$S.\exp (C5F)$
Pour Point	°K	$PP. (1+C6F)$
Flash Point	°C	$FIP. (1+C7F)$
Fire Point	°C	$FiP. (1+C8F)$
Oil-Water Interfacial Tension	mN/m (dyne/cm)	$\theta_{ow} (1+ C69F)$
Oil-Air Interfacial Tension	mN/m (dyne/cm)	$\theta_{oa} (1+ C10F)$