Assessment and Restoration of the BP Llandarcy Refinery Landfill

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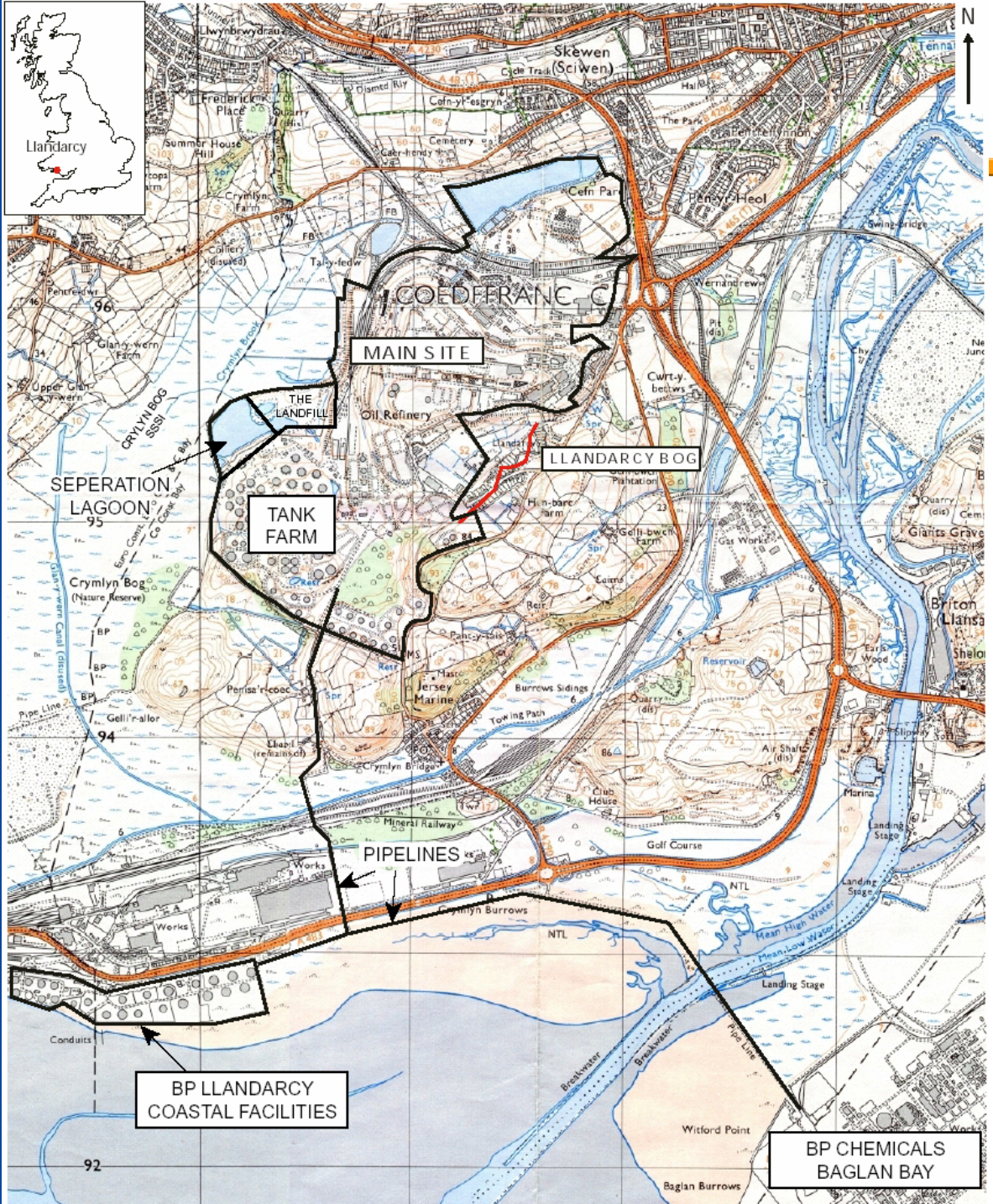
History of the Llandarcy Refinery

- Commissioned in 1921
- UK's oldest refinery
- Peak operation as a fuels refinery in 1970s and early 1980s, at which point it was the UK's largest refinery
- Rationalisations during the mid/late 1980s
- Closure announced in 1997, last lube oil production in June 1998
- Now demolished to grade, except for bitumen plant
- Site now being considered for mixed-use redevelopment as an 'Urban Village'; an environmentally friendly community with residential, recreational and employment areas

Refinery Site Setting

- Total area of operations approximately 350 ha, divided into 2 key areas:
  - Main site – process operations in the north, Tank Farm area in the south
  - Coastal sites – receiving dock, storage and transfer station; linked to main site by overground/underground pipelines
- Main site situated 3 km inland on complex glacial till sequence, overlying fractured sandstone bedrock, drains into Crymlyn Bog; Wales largest SSSI, European SAC, and RAMSAR site
- Coastal sites situated on dune sands, beachfront next to Swansea Bay



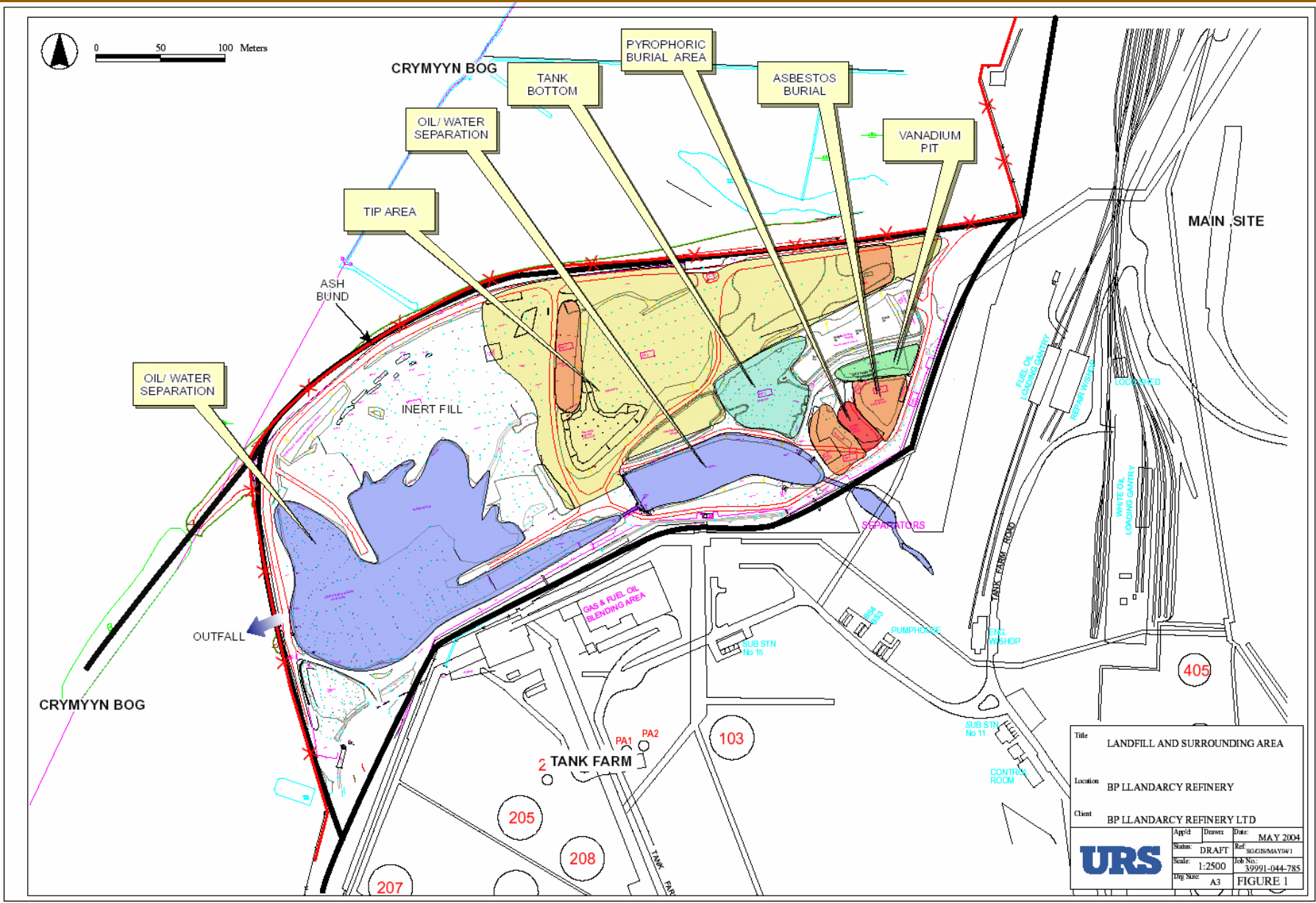
Site Location Plan

Scale: 1 km grid

Landfill History

- Constructed by building semi-circular bund of power station ash into Crymlyn Bog
- Constructed 1939. Principal concept at time of construction was to provide oil containment if storage tanks sustained bomb damage; and several tanks were hit mostly in raids during 1940
- Southern landfill area continued to be used for oil containment and recovery operations, but use of northern area as a licensed disposal site for variety of refinery waste:
  - Pyrophoric waste
  - Fuller's earth clay (used in lube oil production)
  - Refractory waste (from boiler houses)
  - Tank-bottom sludges
  - Demolition rubble
  - Domestic waste
  - Asbestos graves

Landfill Plan



Investigations and Assessment

- Site well-known to regulators (UK Environment Agency, Countryside Council for Wales, Neath Port Talbot Council)
- BP proactive in process: Early involvement of EA, CCW, and NPTCBC in agreeing the design and methodology of investigative and assessment programmes before commencing work
- Quantitative Risk Assessment (QRA) at the centre of the process; focus at this time on offsite environmental and ecological receptors:
  - Crymlyn Bog SSSI
  - Local water receiving bodies
- CCW concerns over water balance and nutrient load also considered in parallel programmesof work through numerical modelling of catchment and sampling programme in the bog itself

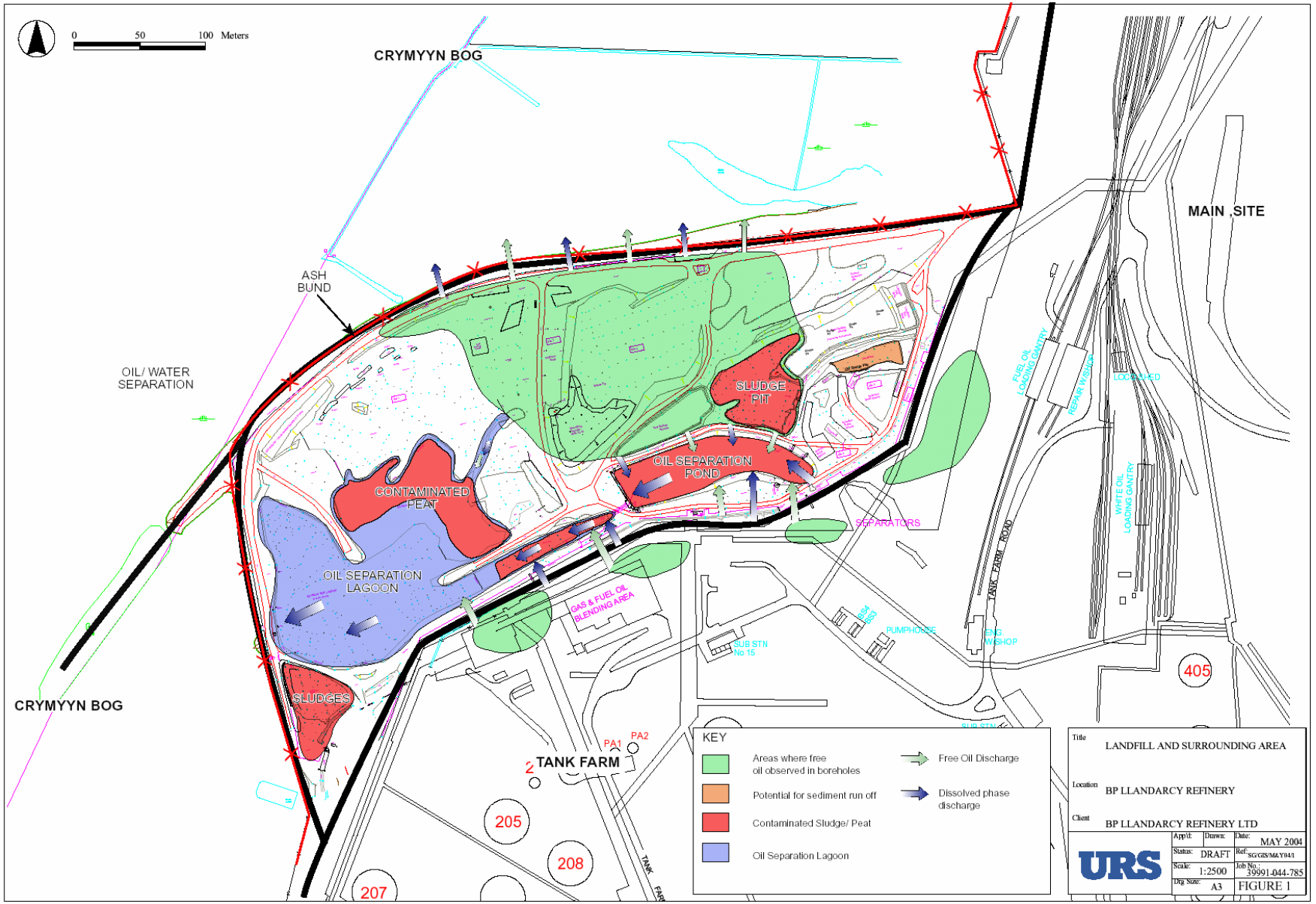
Physical Assessment Findings - 1

- Generally permeable materials in much of the landfill, ie, ash and rubble
- Separation lagoons contaminated around perimeter from oil containment operations
- Potential for vanadium contamination attached to sediment to be washed out of lagoon during periods of high recharge; pyrophoric waste and asbestos immobile
- Pit containing tank-bottom sludge could act as continuing hydrocarbon source
- Surface and groundwater runoff entering separation ponds from refinery likely to be contaminated for a considerable time

Physical Assessment Findings - 2

- Free oil in monitoring wells in landfilled area, up to 2 metres accumulation observed, approximate 1 ha area
- Free oil seepage occurring around perimeter adjacent to bog, currently contained by plywood interceptor, and removed by vacuum trucks
- Oil entering separation lagoon from landfill, and from shallow groundwater from Tank Farm
- Unlike many landfills, no significant gas or landfill leachate issues (except free oil)

Investigation and Assessment Findings



Quantitative Risk Assessment

- Offsite free oil discharge considered unacceptable in principle by BP
- Dissolved-phase hydrocarbons modelled from sources in the landfill and at perimeter. Hydrocarbon type generally weathered and of low solubility
- UK EQS standards used as target values where possible
- Limited comparative ecological target criteria for TPH (ie, no EQS for TPH)
- Transport modelling of hydrocarbons in peat undertaken. Suggested attenuation over short distances in peat aquifer; this confirmed by shallow groundwater samples from bog
- Ecological receptors, ie, key plant assemblages, unlikely to be affected

Remedial Strategy - Administrative

- Major phase of work; likely to take several years to complete.
- Early and open discussions with regulators key to agreement of plan – example, CCW has allowed use of SSSI at site boundary to construct oil interception trenches; recognise overall site betterment
- Understanding from EA on requirements for return of WM licence
- From site redevelopment perspective, necessary to merge remediation with amenity; form as well as function required

Remedial Strategy – Outline Design

- Protect open water areas from free oil discharge
  - Isolate Tip area from Main site
  - Intercept oil entering existing separation lagoon from landfill
  - Intercept oil migrating outward to Crymlyn bog
  - Recover free-phase oil from landfilled area
- Sludge/Waste Treatment
  - Excavate and treat tank-bottom sludge pit
  - Treat contaminated materials from separation lagoons
  - Stabilise vanadium lagoon
- Dissolved-Phase Hydrocarbon Flux Control
  - Encourage/construct reedbeds as sustainable and attractive way to reduce dissolved hydrocarbon in runoff; pilot tests completed in 2003
- Amenity Development
  - Landscaping, to improve aspect of area, but also including permeable cap to maintain hydraulic gradients and promote mobility of remaining free-phase oil

Conceptual Remedial Approach