

ON THE SIGNIFICANCE OF AERATION IN THE ASSESSMENT OF EROSION OF UNLINED SPILLWAYS

Lily Wu, Bill Peirson, Steven Pells, Kurt Douglas and Brett Miller

Erosion of unlined spillways – present programme

- Many spillways discharge into an unlined rock channel.
- The unlined channel is sited in rock judged to be resistant to erosion at least for high frequency floods.
- However, there have been a few spillways which have experienced unanticipated erosion.
 - Is there an unrecognised risk?
 - There has certainly been an unrecognised cost
- When do aging spillway slabs become vulnerable?



Erosion of unlined spillways

Why should we worry about aeration?

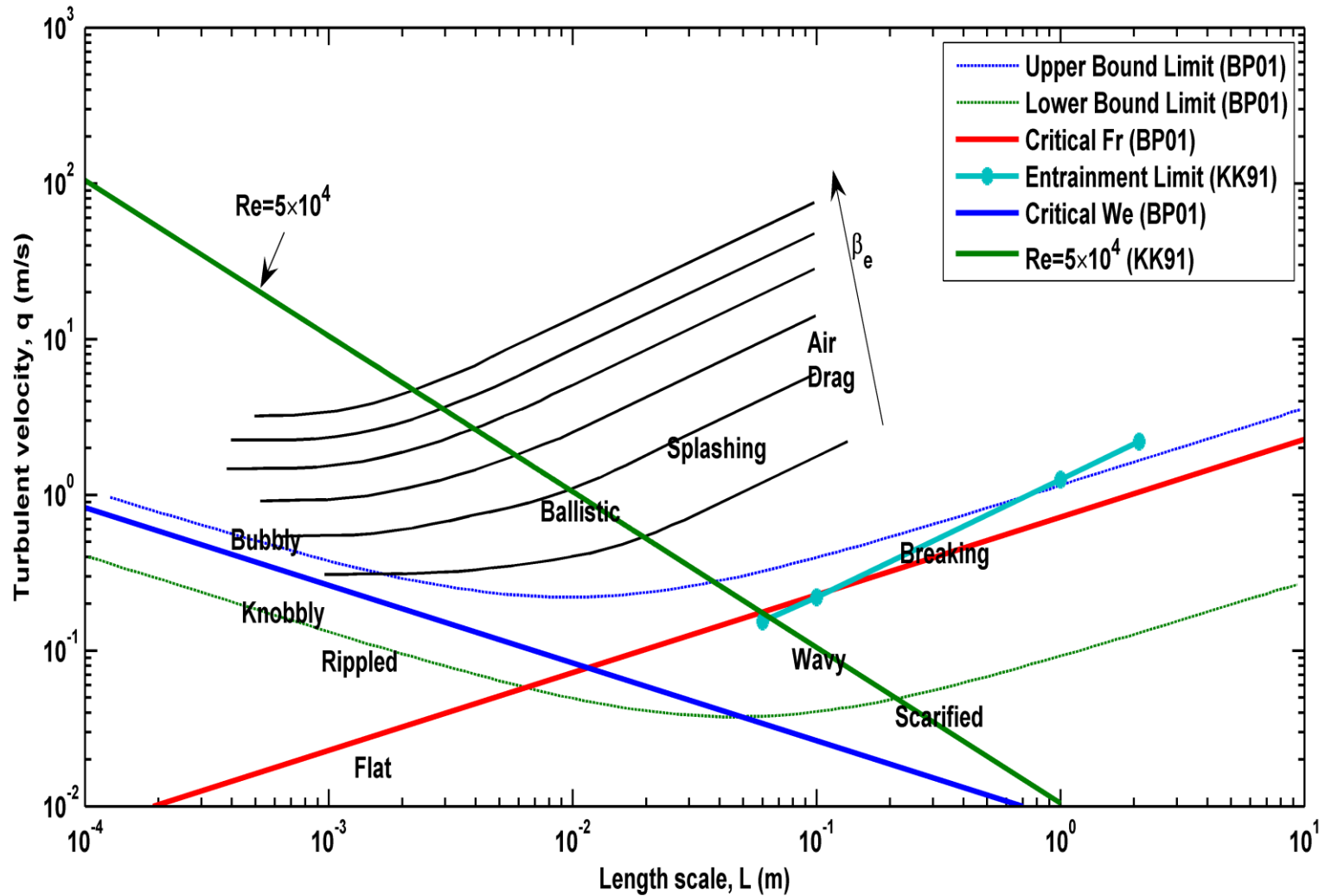
- Aeration significantly reduces spillway drag.
- A review of design methods for steep rockfill spillways showed unreconciled diversity in German, British and American design approaches.
- Peirson and Cameron (2006, JHE) showed these approaches could be reconciled once aeration included.
- Placement significantly changes bulk density and stability (Peirson et al., 2008, JHE)
- How important is aeration as a source of uncertainty in the assessment of unlined channels?



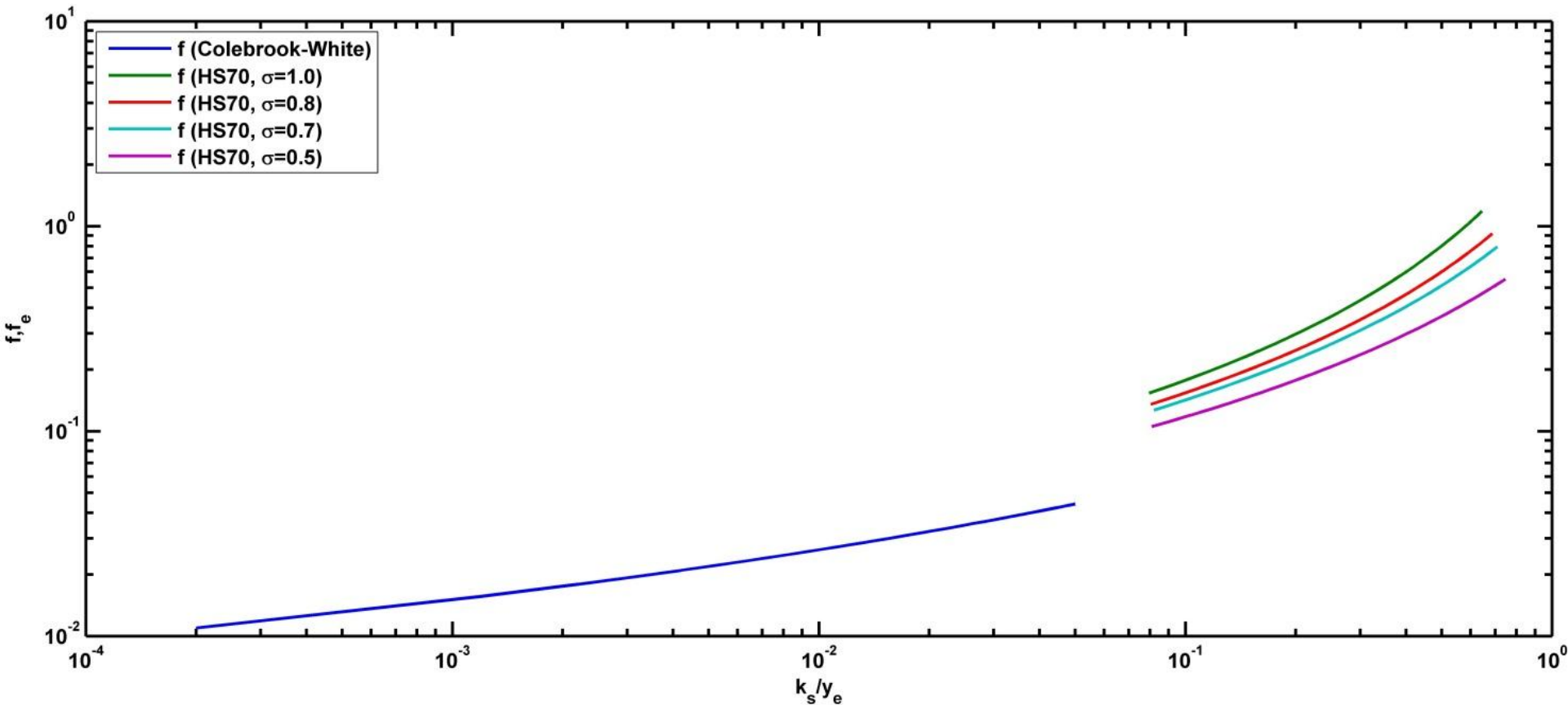
Key issue – we do not understand the hydraulics of aerated flow (Ceccio, 2010)

- Approaches are diverse:
 - Non-dimensional
 - Microphysical
- For water, Froude, Reynolds and Weber characterisations are interdependent.
- Primary objective – reconciliation:
 - Large-scale: Kobus and Koschitzky (1991)
 - Micro-scale: Brocchini and Peregrine (2001)
- These approaches can be reconciled





Relative roughness



Status of numerical modelling

- Sabbagh-Yazdi et al. [2008]
 - Flow-3D/ Reynolds/ VOF
 - Cain and Wood [1983]
 - Aeration sub-model sim. to Brocchini and Peregrine [2001]
 - point of inception, mean velocities, mean air conc. OK
- Cheng et al. [2006]
 - Fluent/ turbulent flow of mixtures.
 - single bubble size of 5mm.
 - Qualitatively - cavity recirculation
 - Captured observed velocity profiles and surface pressures
- Ones to watch:
 - Gerris [Popinet, 2003] - complex 3D aerated surface structure.
 - Smoothed particle hydrodynamics (SPH) – instabilities?



Conclusions and recommendations

- Good reconciliation between microphysical approaches to aeration and non-dimensionalisation of large-scale data.
- Drag on rock spillways three-fold **enhancement** over widely-used expressions based on pipe-test data. Emergence?
- Numerical techniques to represent aeration have been developed which have been calibrated to limited test data. Blind predictive ability has not been demonstrated.
- Large-scale physical investigations now directed at reconciling recently-developed mechanical/energetic coupling approaches for unlined spillways. Aeration will play a significant role on steep slopes.

