Meeting new challenges in minesite landform design

Rob Loch

Historically ….

- Waste landforms were not designed;
- Similar profiles used worldwide
- No consideration of site materials & climate;
- Poor aesthetics;
- Commonly unstable; and
- Failure to meet community expectations.

Metalliferous mines (gold)

Coal mines (Qld)

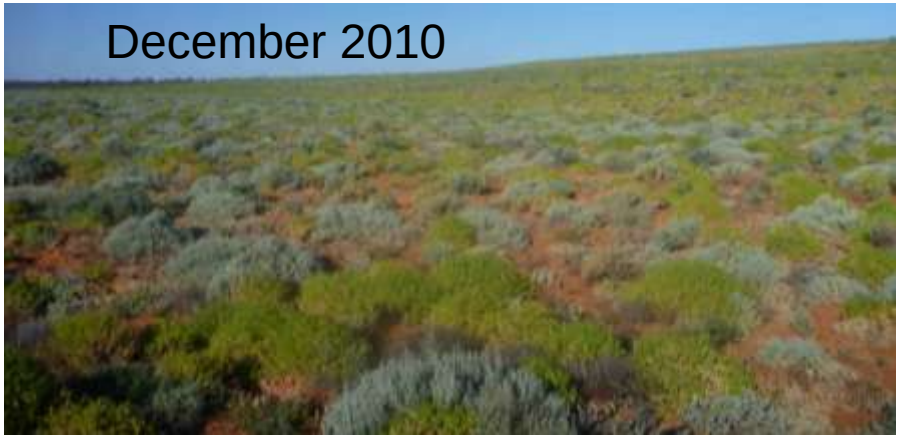
Coal mines (Hunter)

An alternative approach

Landform and erosion modelling has been used since late 1990's to produce:

- Site- and material-specific landforms
- Wide range of landforms
- Demonstrated stability
- Geomorphically sound landform approaches.

Example #1: Sand mine, NSW



- Linear slopes;
- Low gradients;
- Use of tree debris
- Control of flows.

Example #2: Gold mine, WA

- Concave slopes;
- Soil amelioration;
- Use of tree debris;
- Control of flows.

Example #3: Dredge spoil, WA

- Linear slopes;
- Preparation of rocky cover material;
- Soil amendment and fertilisation.

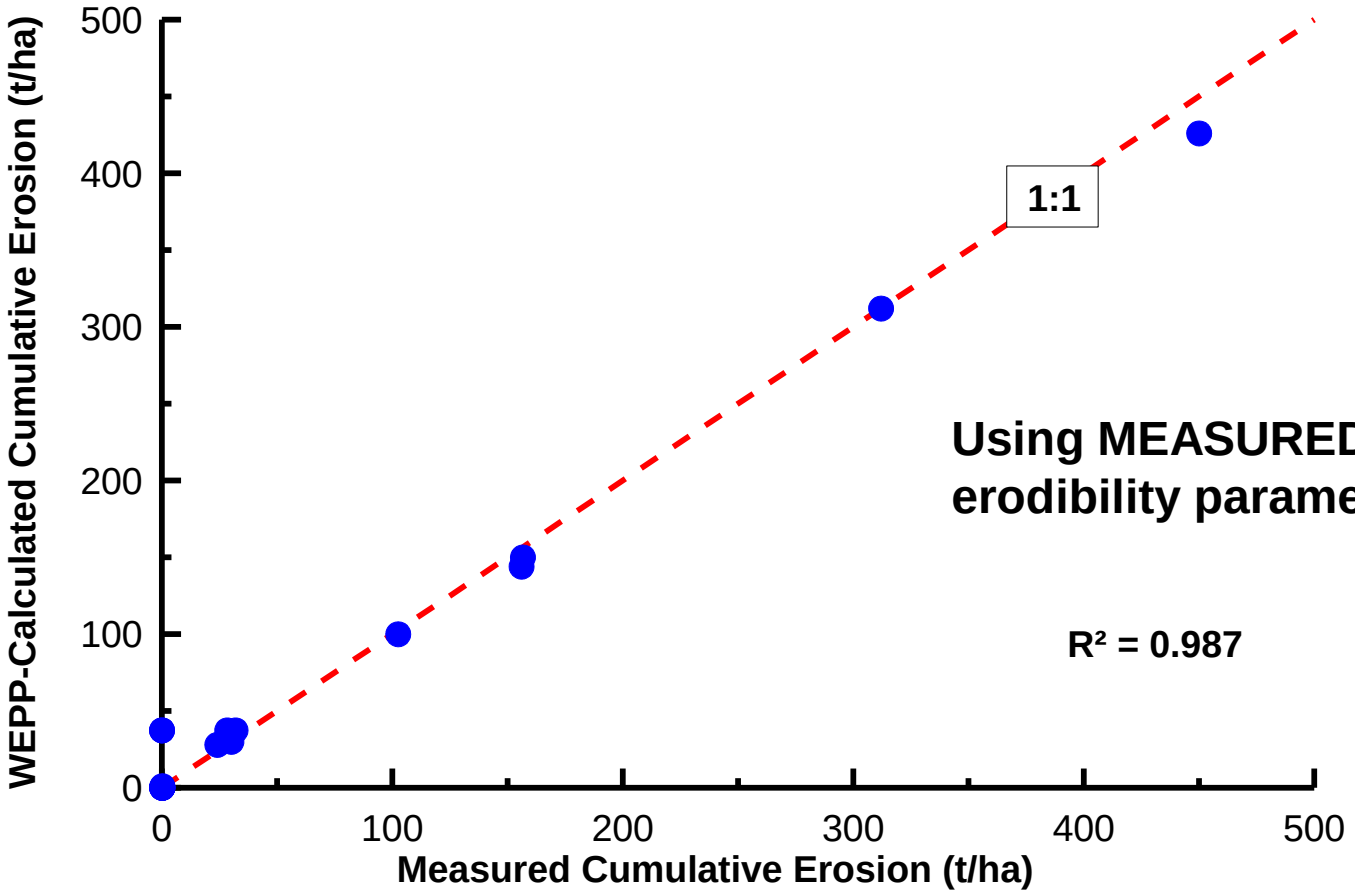
What have we learnt?

- Can produce a wide variety of designs and excellent outcomes
- Modelling can be very accurate
- Most critical where erosion hazard greatest
- Provides a wide range of soil management and landscape guidance
- High potential for development of aesthetically acceptable landforms

Accuracy

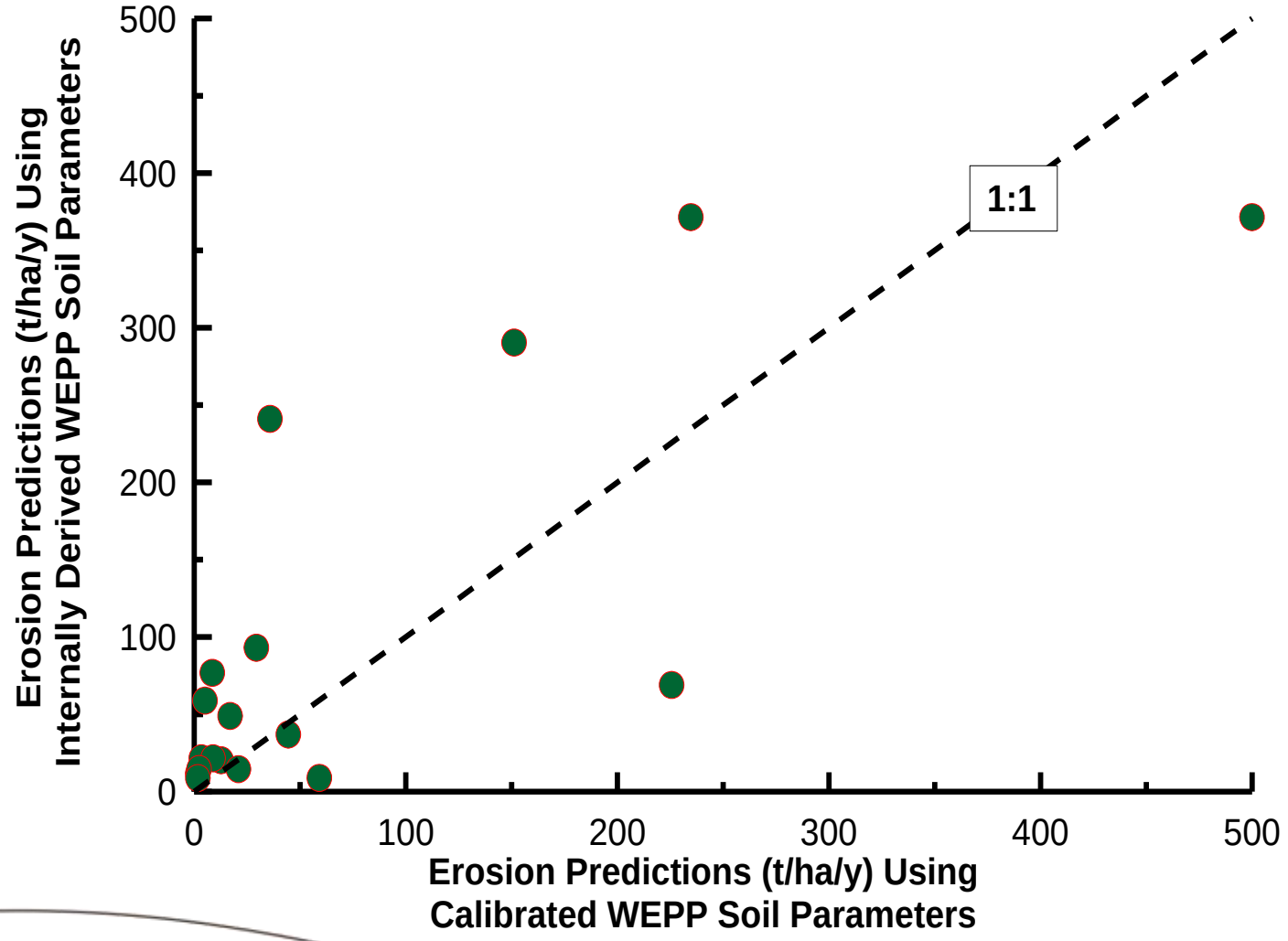
- Performance of constructed designs has been assessed;
- Very close agreement between predicted and observed erosion; but
- Critical to use measured parameters; so
- Quality in landform design planning is critical.

Accuracy of design simulations

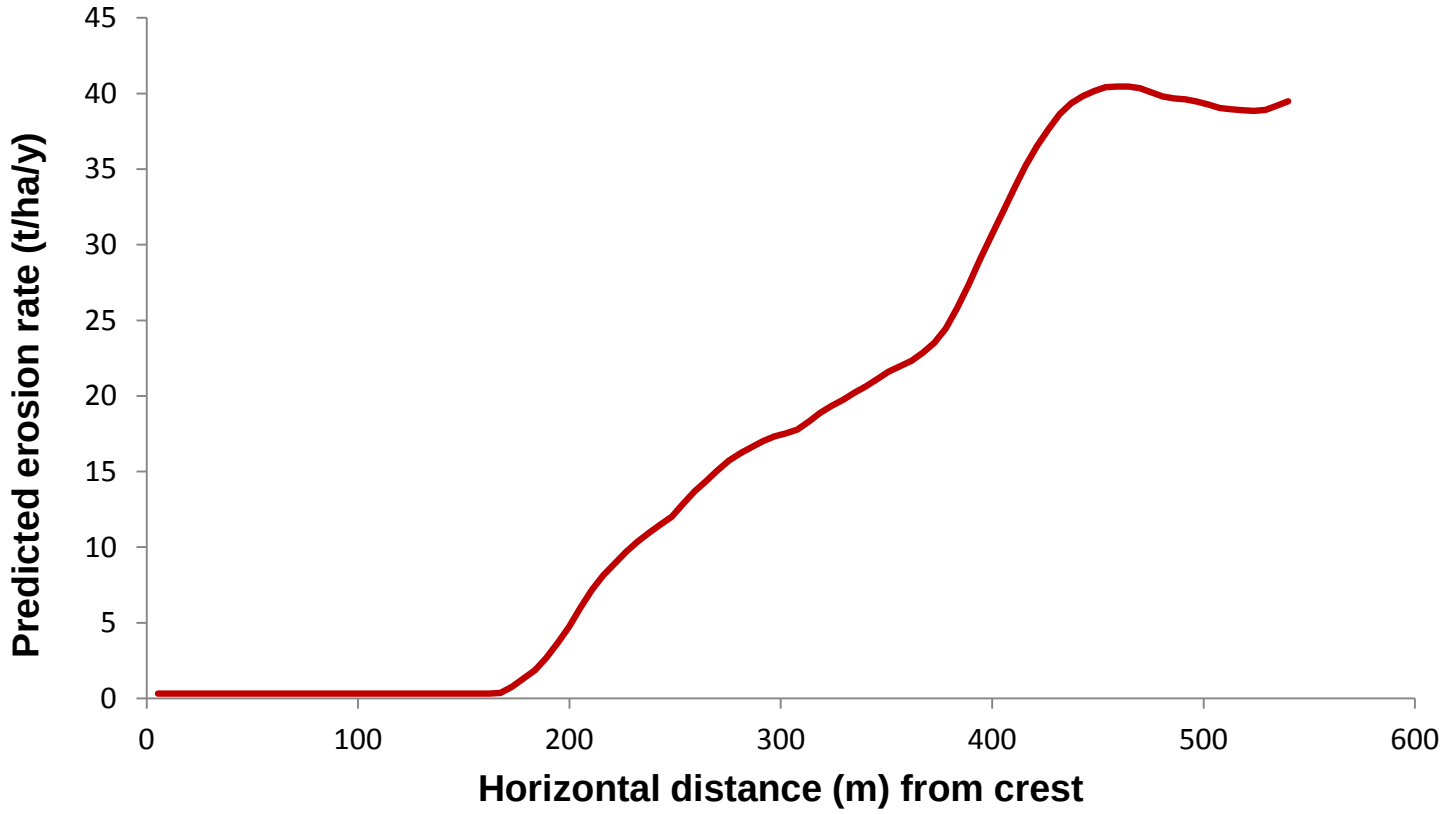


Predicted and observed cumulative erosion rates for 20 batter slope locations on Western Australian mine sites

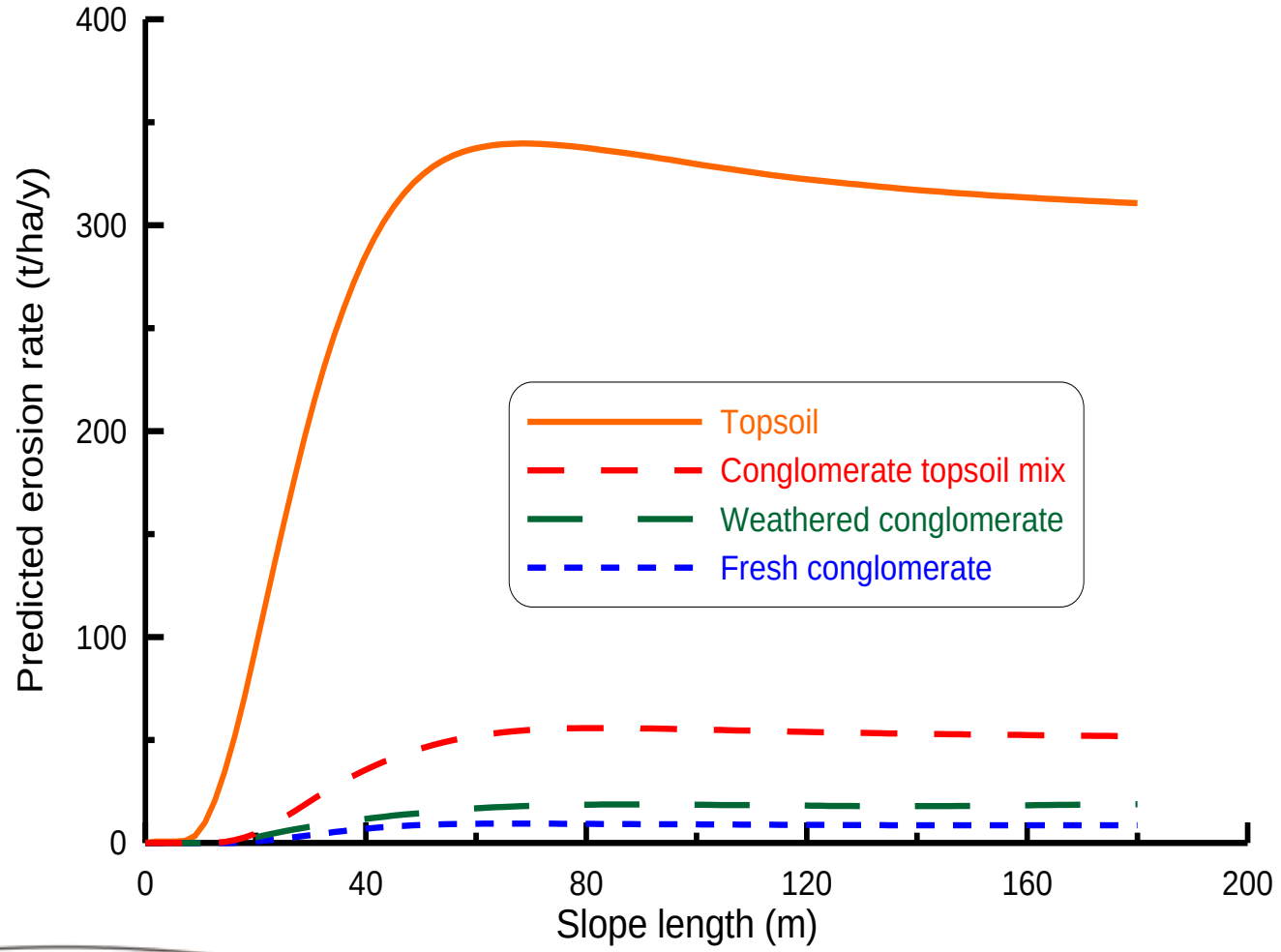
But parameter inputs are critical



Risk and slope height

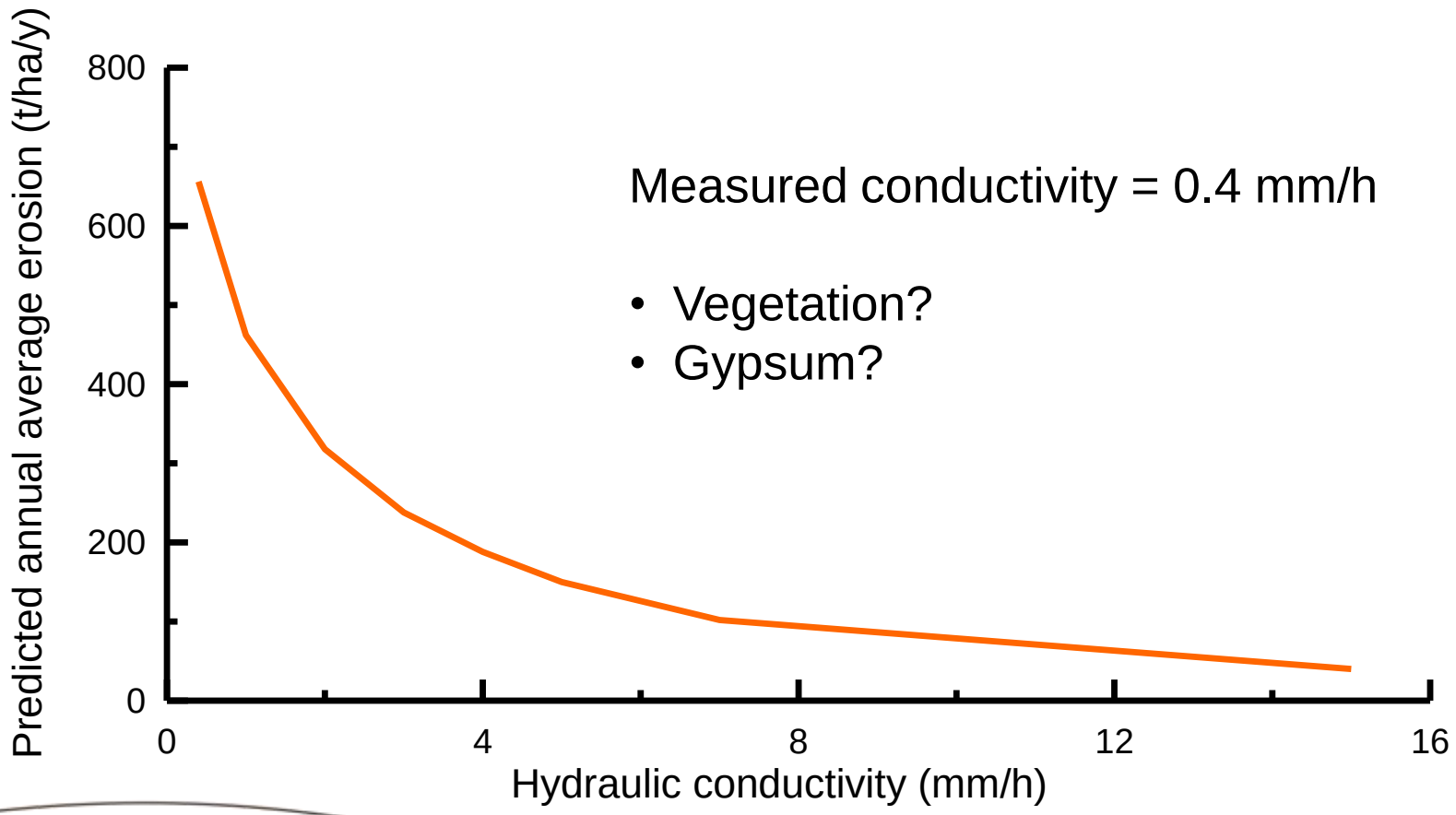


Risk and soil erodibility



Risk and soil infiltration capacity

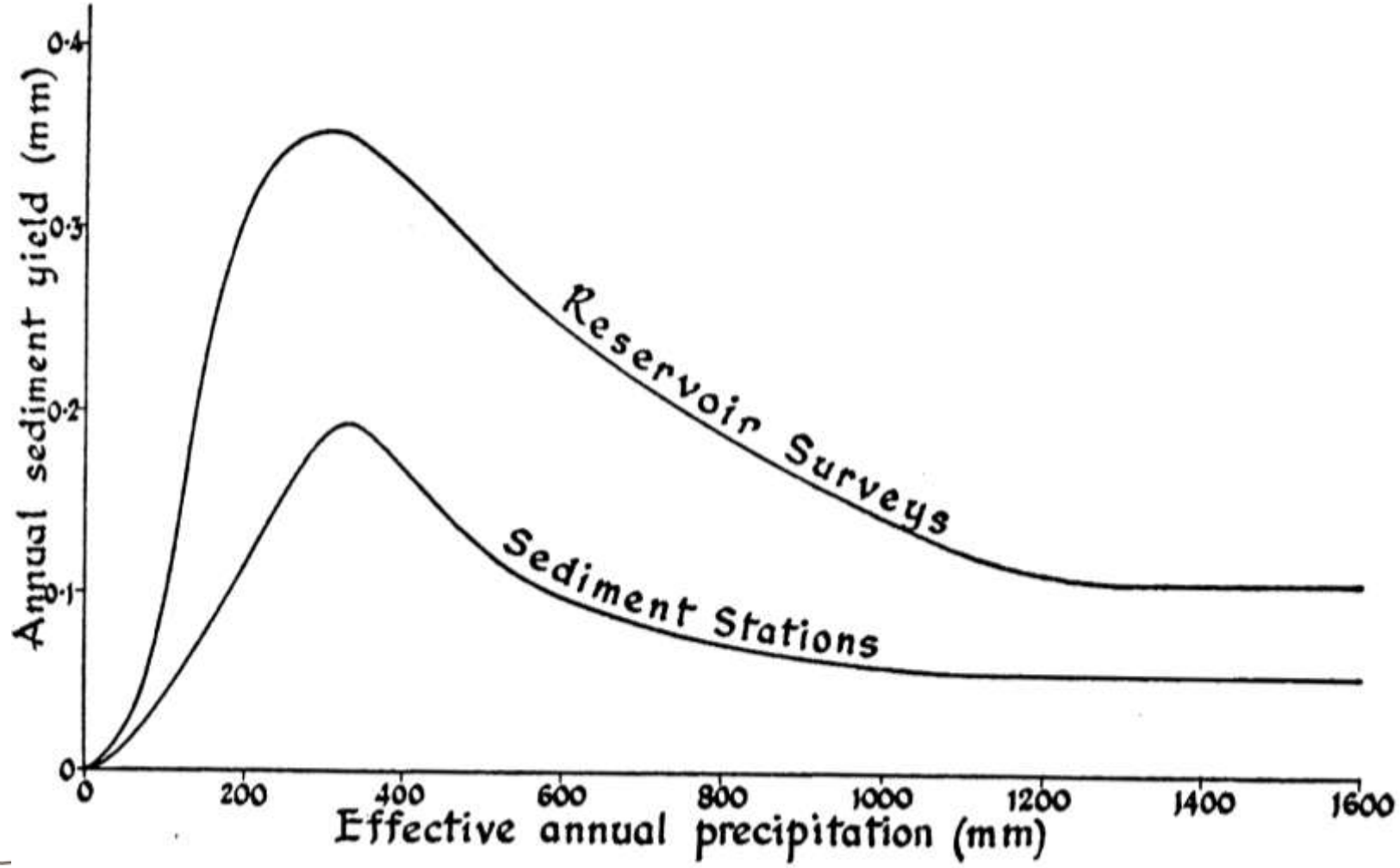
Potential impact of soil improvement



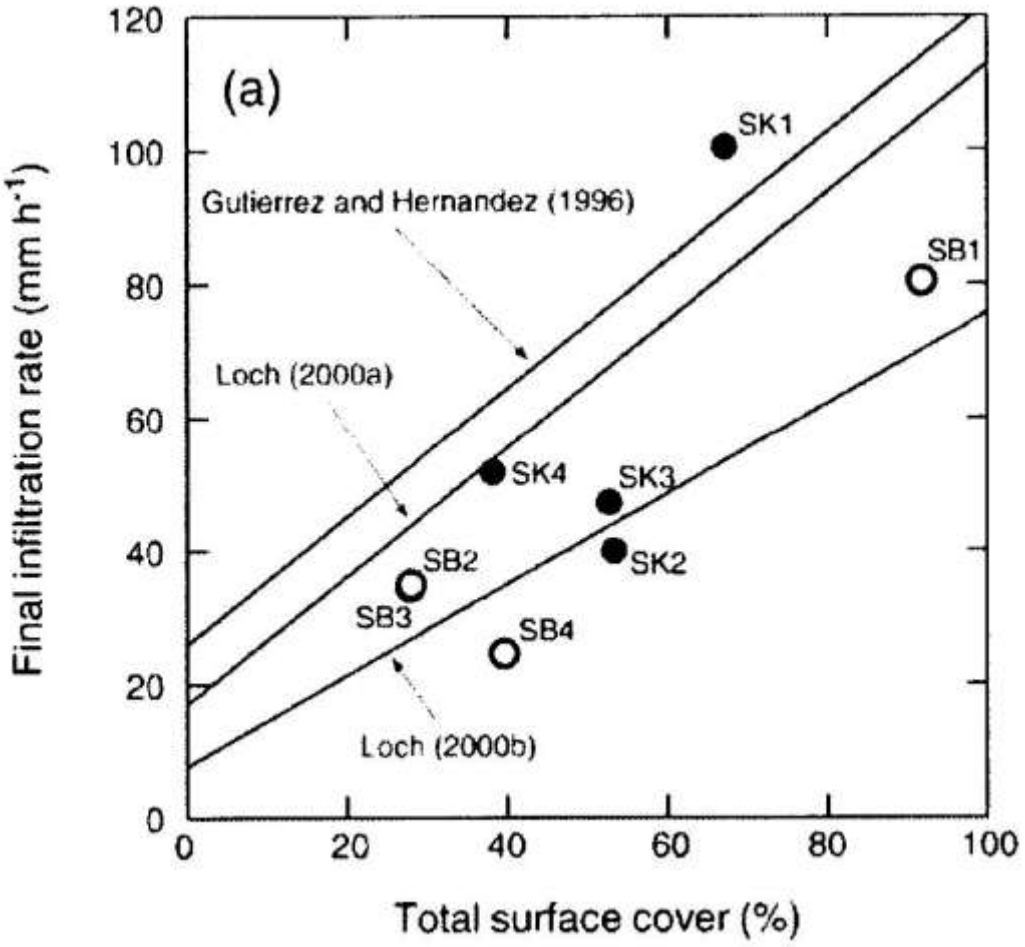
Measured conductivity = 0.4 mm/h

- Vegetation?
- Gypsum?

Risk and Climate



Impacts of vegetation



Management guidance

Modelling approach and associated assessments can guide:

- Progressive rehabilitation to deal with high slopes;
- Soil amendment to increase infiltration and reduce erodibility;
- Identification of targets for revegetation (cover); and
- Soil treatment (fertiliser) to ensure vegetation targets are met.

Risk factors

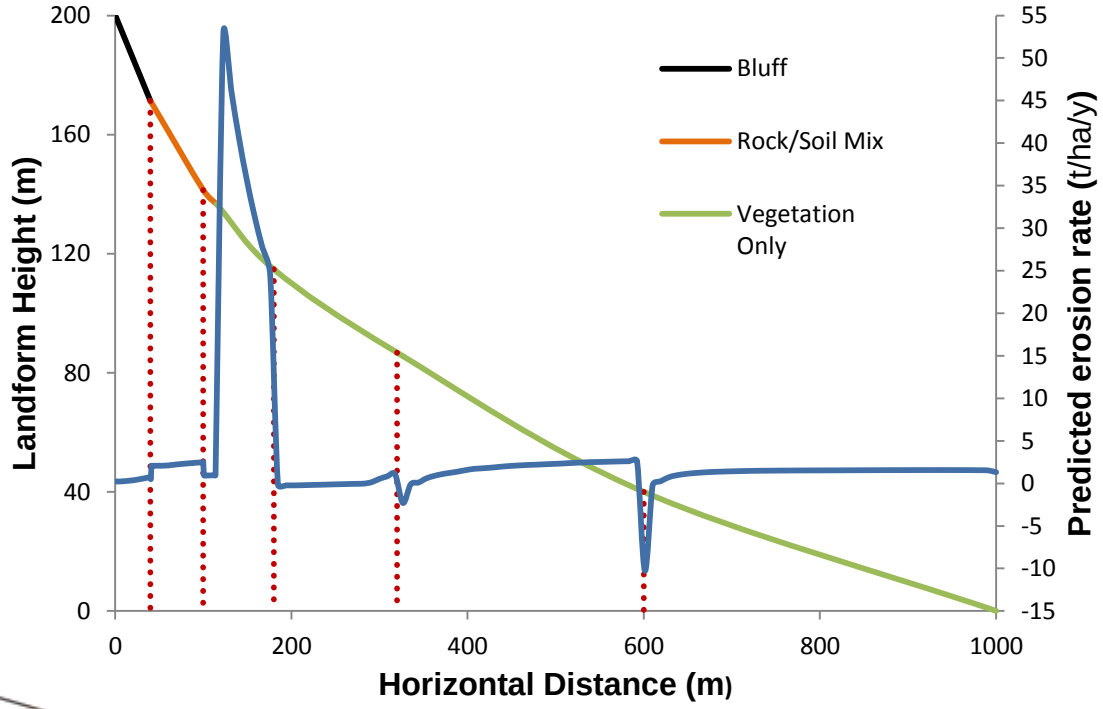
Low risk	High risk
Rain >500 mm/y	Rain ~300 mm/y
Non-erodible soils	Erodible soils
Non-dispersive soils	Dispersive & tunnel-prone
Good vegetation growth	Poor vegetation growth
Low gradient slopes	High gradient slopes
Low slopes (≤ 60 m vertical)	High slopes (up to 200 m vertical)

Capacity to design “natural” landforms

Concave profiles

Able to consider spatially variable materials

Rocky bluffs, zones of varying erodibility



Also able to:

- Incorporate swales and flow paths;
- Assess 3-D erosion patterns; and
- View the final vegetated product.

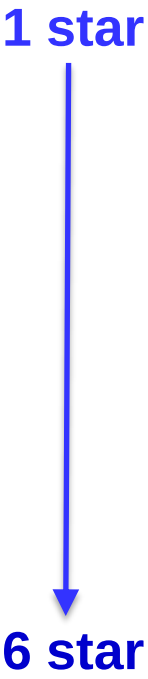
Considering aesthetics

- No single, identifiable, "natural" landform shape or profile;
- Mimicking nearby landforms may be dysfunctional;
- Personal opinions of aesthetic quality may vary greatly;
- Need some way to rate / assess aesthetic "quality".

Aesthetics: a “less bad” rating

Landloch has used a progression of:

1. Functionality (stability, water quality);
2. Sustainability (vegetation);
3. Non-linear batters (concave profile);
4. Non-linear plan footprint;
5. Non-linear top outline;
6. Geomorphic features (swales, cliffs).



So basically 3 design options:

1. Mimic natural landforms.

2. Mimic natural landforms, assess with erosion and landform evolution models.

3. Design using models and typical landform features.

Pros and cons of design options

Option 1 (Natural Design only) may well not be stable if:

- Topsoil and waste are more erodible than "natural" soil and rock;
- Vegetation performance is poorer than in analogue areas; and/or
- Climate change alters erosion risk.

Clearly best applied in low-risk situations.

Pros and cons of design options

Option 2 (Natural Design followed by erosion/landform modelling) will achieve:

- Initial design based on natural landforms;
- Modification of the design to ensure stability and sustainability;
- Guidance on material management and rehabilitation practices; and
- Demonstrated landform stability.

Applicable to higher risk situations.

Pros and cons of design options

Option 3 (Design using erosion/landform modelling) can achieve:

- Stable, sustainable design based on natural landforms;
- Guidance on material management and rehabilitation practices; and
- Demonstrated landform stability.

Applicable to higher risk situations.

Assessing options

Deciding the optimal approach may not be easy, but:

- It IS more appropriate for a landform to be designed on the basis of site climate and soil properties than on the properties of the surrounding hills; and
- There is no such thing as an "exactly natural" landform; there is scope for considerable variation.