FACTORS INFLUENCING THE LIKELIHOOD OF INITIATION OF INTERNAL EROSION THROUGH THE FOUNDATION **DATE: JULY 2012**

The factors below from the table for Internal Erosion Through an Embankment Dam also apply to this category of Internal Erosion of through the Foundation. Minor adjustments to the wording are required for some of the factors to be applicable solely to the foundation. Some considerations for adjustments are presented below, and judgment must be exercised as well.

Seepage
Soil Erodibility
Sinkholes or depressions – Sinkholes or depressions observed on the embankment surface may indicate collapse of the embankment into an erosion pathway in the foundation.
Differential settlement of foundation – Differential settlement in the foundation may crack the foundation soils as well as the overlying embankment.
Desiccation cracking – Desiccation cracks in a soil foundation might not have been completely removed prior to placing the embankment materials.
Reservoir operation – Erosion in the foundation might only occur during peak reservoir levels. Additionally, drought periods may allow for damage to the foundation by animals.
Extensive vegetation, root balls, rodent holes
Age of dam / length of service

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Factor	**Influence on Likelihood / Relative to Reclamation Historical Base Rates (see notes)**			**Comments**
	Less Likely	**Neutral**	**More Likely**	
Foundation soil characteristics				Refer to erodibility of soils for general considerations
Backward Erosion Piping	Cohesive soils with PI>7 Pockets of cohesionless soils that are not continuous		Fine, cohesionless soils continuous from upstream to downstream	
Scour or Internal Migration	No open-work foundation soils	Some coarse-grained deposits exist, but of questionable continuity and not particularly high porosity	Continuous layers of high porosity or open-work gravels and/or cobbles	
Suffusion/suffosion	Soils not susceptible to internal instability		Glacial soils Soils with gradations susceptible to suffusion/suffosion	
Presence of karstic features	Much less likely – no karstic features present	Karstic features are at depth or were recognized and properly treated	Features such as solution channels, brecciated zones, ancient chimneys and similar were present beneath dam footprint, with marginal treatment measures	
Foundation grouting	Multiple row grout curtain in rock foundation;	Single row grout curtain in rock foundation; typical USBR grouting practices employed	No grouting of bedrock foundation that appears to have potential for seepage	Improperly designed and executed grouting programs can lead to windows for concentrated flow and high gradients. Additional considerations include angle of grouting (vs. joint orientation) and grout

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Factor	**Influence on Likelihood / Relative to Reclamation Historical Base Rates (see notes)**			**Comments**
	Less Likely	**Neutral**	**More Likely**	
				closure criteria.
Presence of bedrock discontinuities	Minimal rock jointing and fracturing reported Much less likely if bedrock reported to be massive	Some bedrock discontinuities reported, but no widespread areas of fracturing/jointing	Embankment footprint contains large areas of significantly jointed or fractured bedrock, or contains prominent continuous joints or fracture patterns	The continuity of any bedrock feature such as a fault, joint, or fracture system is an important factor as to whether a seepage path will develop
Nature of bedrock discontinuities	Bedrock joints and fractures reported or observed to be tight	Bedrock joints or fractures reported or observed to be relatively tight, infilled, or open only a few millimeters	Bedrock joints and fractures reported or observed to be open several millimeters to centimeters (or larger)	Aperture size is related to the velocity of water and some weaker bedrock types with large, open discontinuities could be erodible

Notes on use of Table:

1. Table is intended to provide guidance in addition to historical base rates of initiation of internal erosion. The neutral factors listed in the table would correspond to average base rates. Neutral factors do not imply a 50% probability. In general for a given Reclamation dam, there would be justification to select a probability of initiation of internal erosion higher than historical base rates if that dam was characterized by multiple "more likely" factors listed above; and conversely, there would be justification to select a probability of initiation of internal erosion lower than historical base rates if that dam was characterized by multiple "less likely" factors. Whether the estimated probability of initiation of internal erosion is higher, lower or near the historical base rate, the justification for the estimated probability must be documented. This table provides some guidance for that justification.

2. Some factors listed on the table apply to all internal erosion mechanisms (backward erosion piping, internal migration, scour, suffusion/suffosion) while some factors might only apply to one mechanism.

3. Some factors listed on the table are more critical to initiation of internal erosion than others. In general, more influential factors are listed towards the top of the table and less influential factors are listed towards the bottom.

4. For some factors, the "Less likely" column also includes factors that would make the probability of initiation "much less likely."

5. Expert guidance is critical for interpreting observations at a dam and making judgments that relate performance of a specific dam to historical base rates of internal erosion.

References:

Fell, R. and C.F. Wan (2004), "Methods for Estimating the Probability of Failure of Embankment Dams by Internal Erosion and Piping in the Foundation and from Embankment to Foundation," University of New South Wales, Sydney, Australia. UNICIV Report 436. January 2004.

"A Method for Estimating Probabilities of Failure of Embankment Dams due to Internal Erosion," USACE Internal Erosion Toolbox, Best Practices Guidance Document, Final Draft, January 2010.