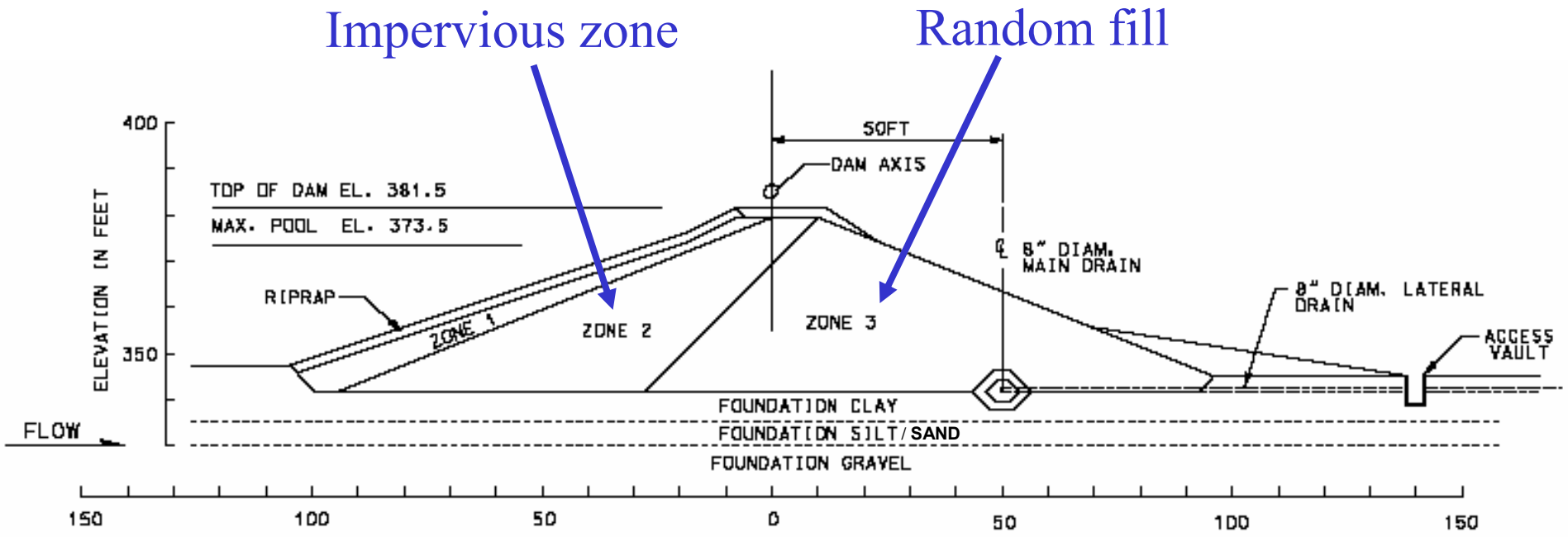
Internal Erosion & Piping at Fern Ridge Dam

Jeremy Britton
U. S. Army Corps of Engineers
Portland District

Project Location

Fern Ridge Project

FERN RIDGE DAM


Impervious zone
Random fill
400
350
ELEVATION IN FEET
50FT
DAM AXIS
TOP OF DAM EL. 381.5
MAX. POOL EL. 373.5
℄ 8" DIAM.
MAIN DRAIN
8" DIAM. LATERAL
DRAIN
ACCESS
VAULT
RIPRAP
ZONE 1
ZONE 2
ZONE 3
FOUNDATION CLAY
FOUNDATION SILT/SAND
FOUNDATION GRAVEL
FLOW
150
100
50
0
50
100
150

TWO PROBLEMS

1) Internal Erosion & Piping
   – Current Repair

2) Liquefaction in the Foundation Silty Sand

OBSERVATIONS OF DISTRESS IN LAST 3 YEARS

Depressions on downstream slope (3)

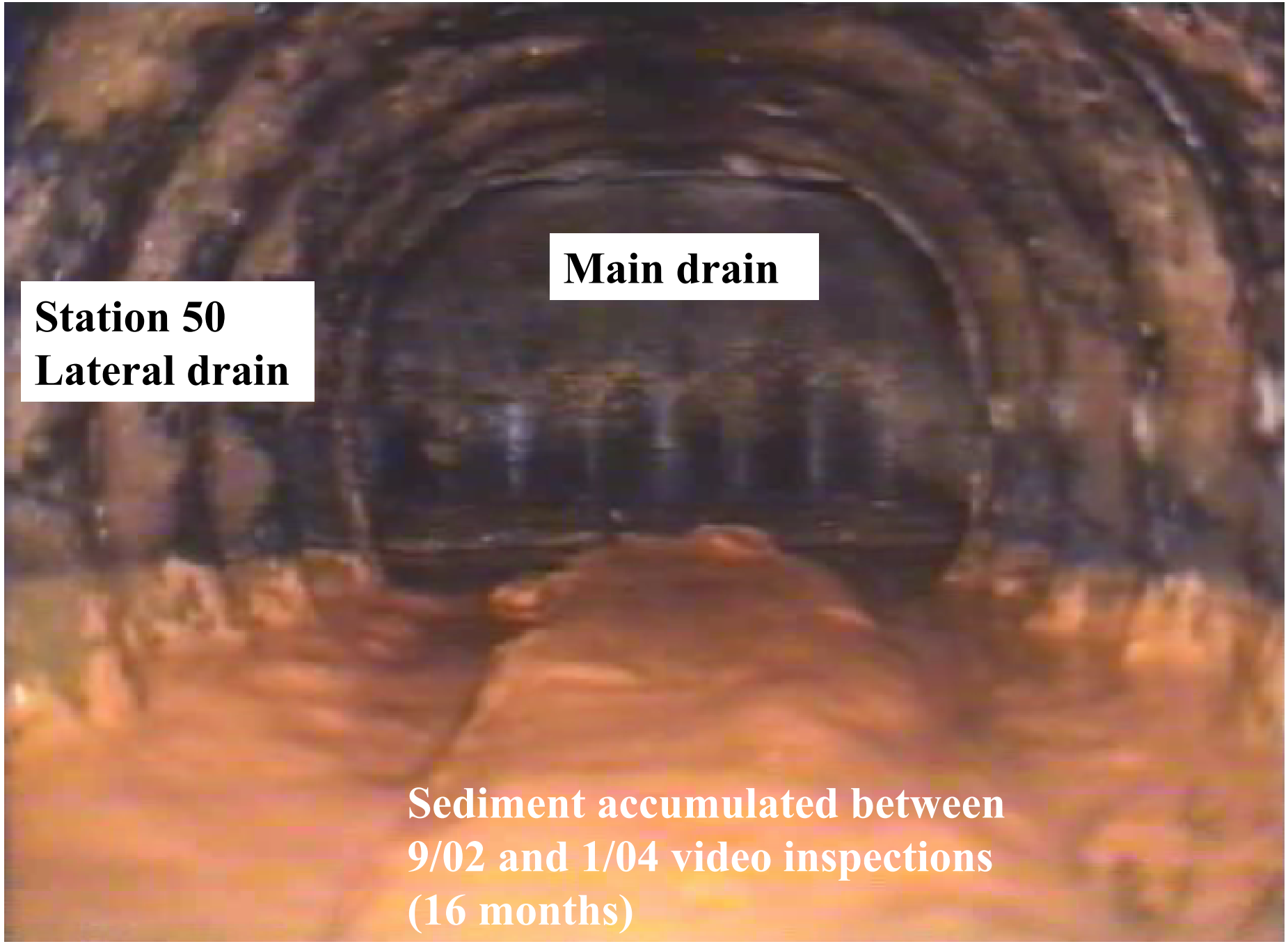
- 5 – 20 ft in diameter, 8 – 12 inches deep

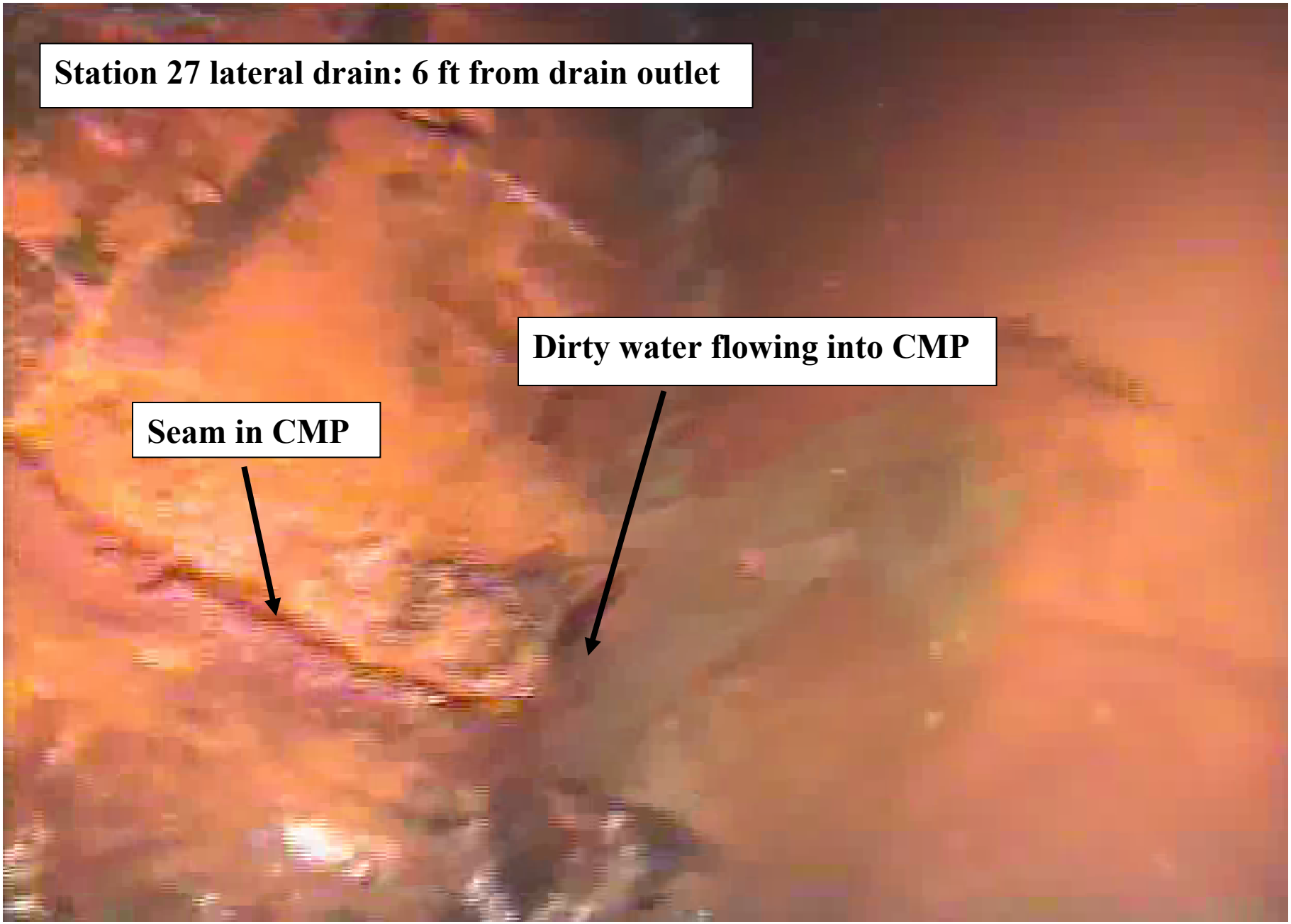
Spikes in lateral drain flows during rain events

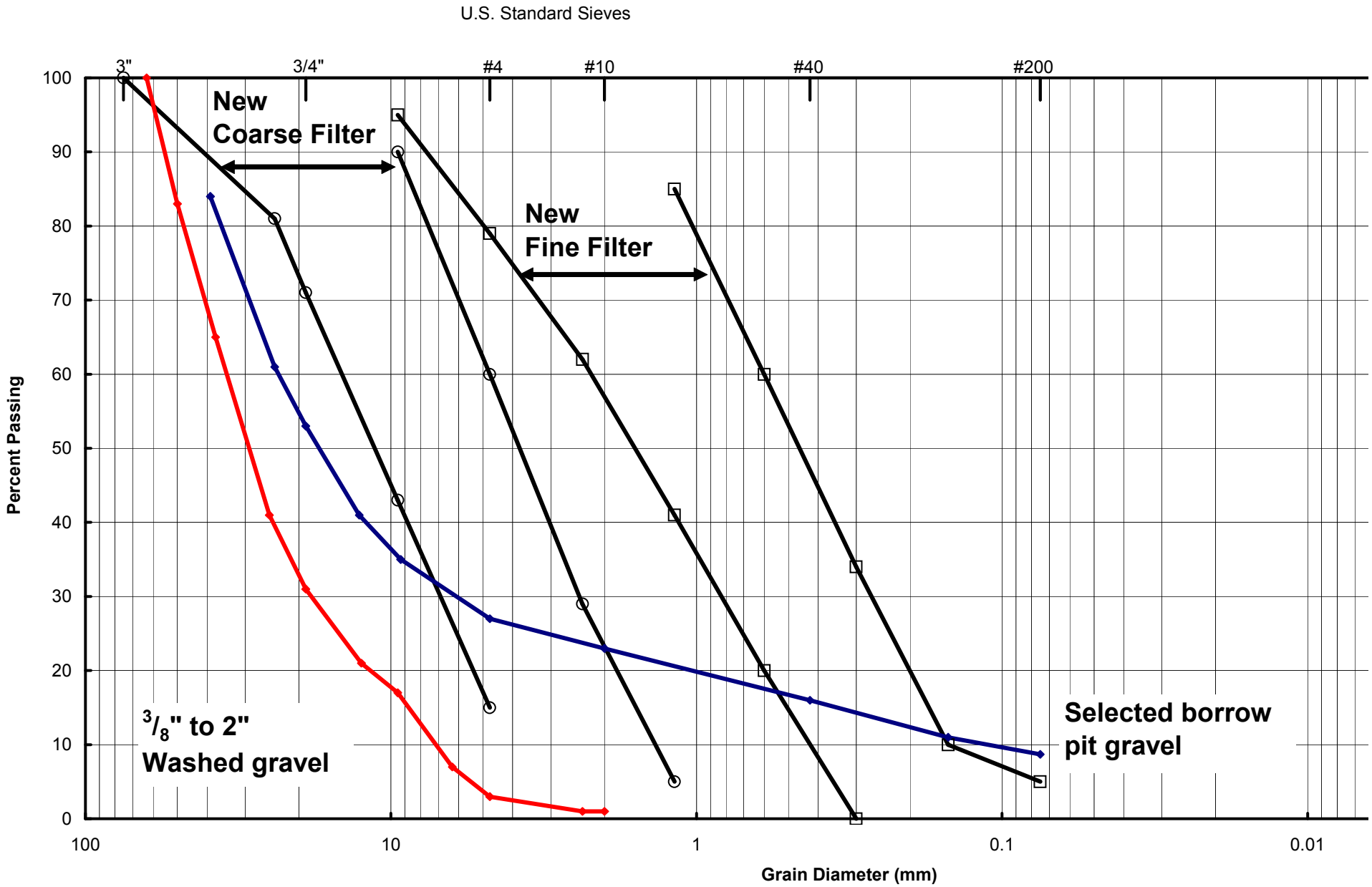
- Normal summer flows: trickle to 4 gpm *
- Heavy rains cause spikes of up to 10 gpm

Sediment transport in lateral drains

- Several drains carry clay, silt, and sand
- * Sta. 45: normal flow = 7 – 10 gpm; 5 – 10 lbs per month accumulating behind weir [15% organics, 55% fines (MH), 30% sand]


Main drain
Station 50
Lateral drain
Sediment accumulated between
9/02 and 1/04 video inspections
(16 months)


Station 27 lateral drain: 6 ft from drain outlet
Dirty water flowing into CMP
Seam in CMP

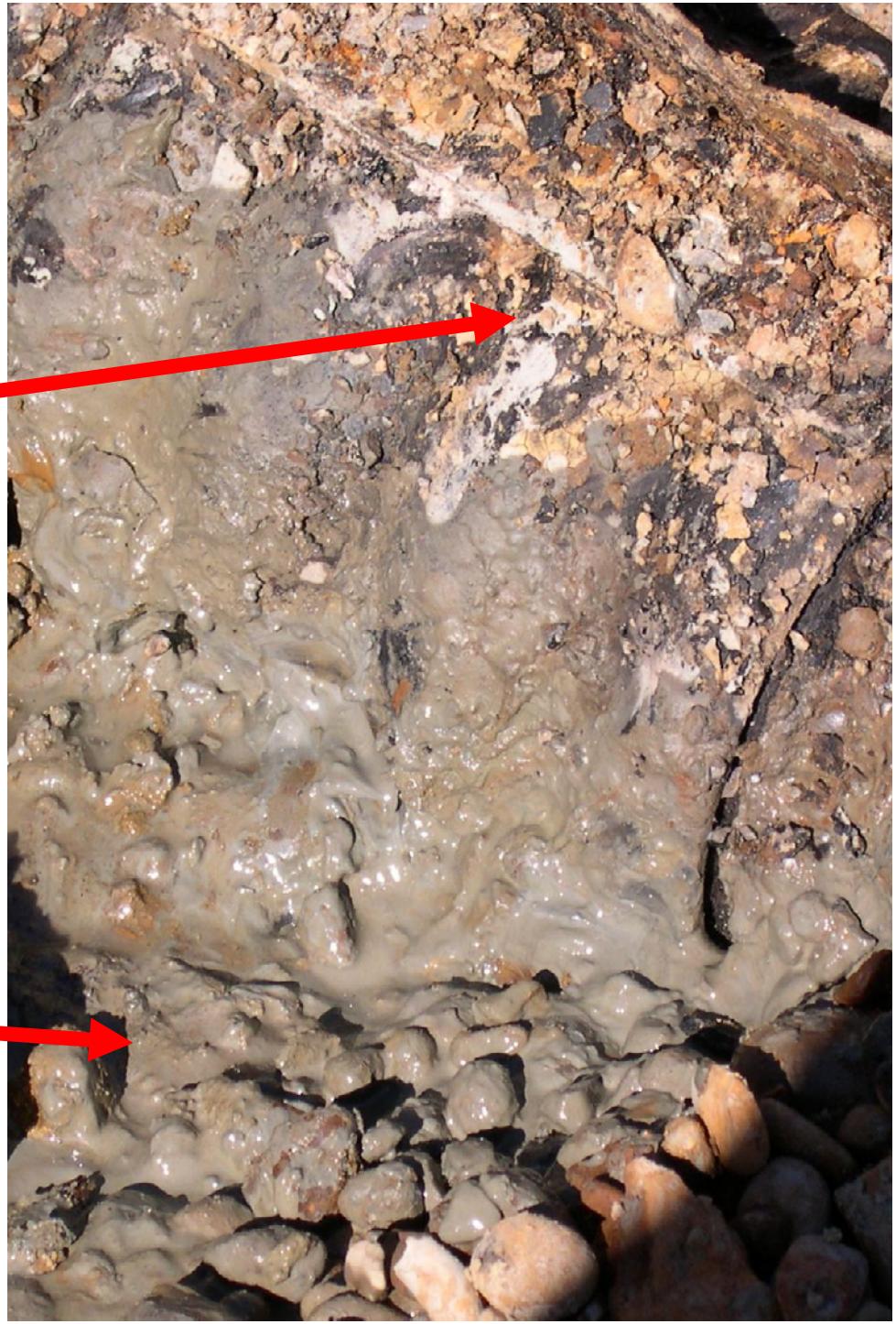

U.S. Standard Sieves
3"
3/4"
#4
#10
#40
#200
100
90
80
70
60
50
40
30
20
10
0
Percent Passing
New
Coarse Filter
New
Fine Filter
3/8" to 2"
Washed gravel
Selected borrow
pit gravel
100
10
1
0.1
0.01
Grain Diameter (mm)

Selected borrow pit gravel

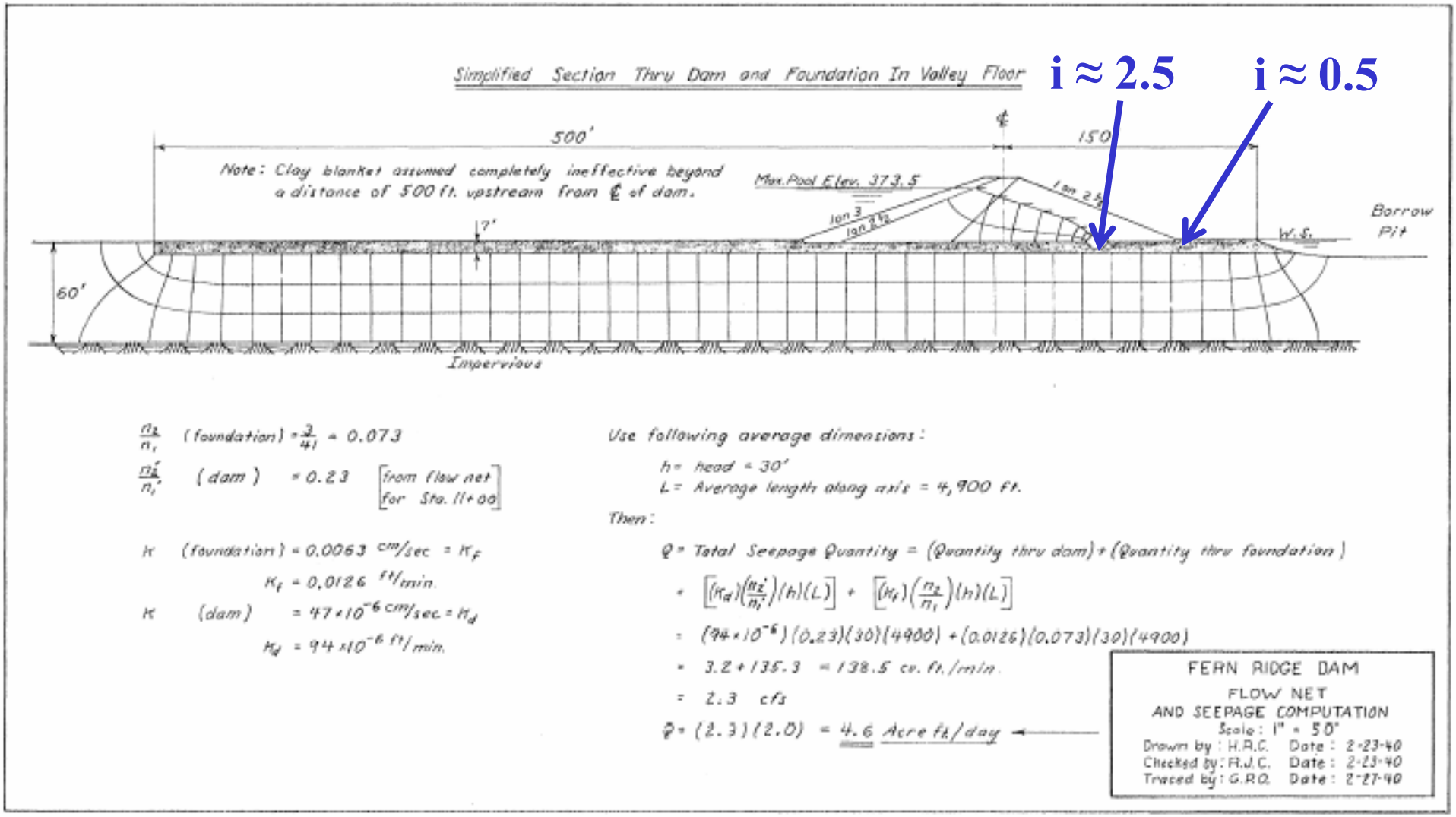
$^{3}/_{8}$” to 2” Washed gravel

Lateral drain coupling band

$^{3}/_{8}$” to 2” Washed gravel

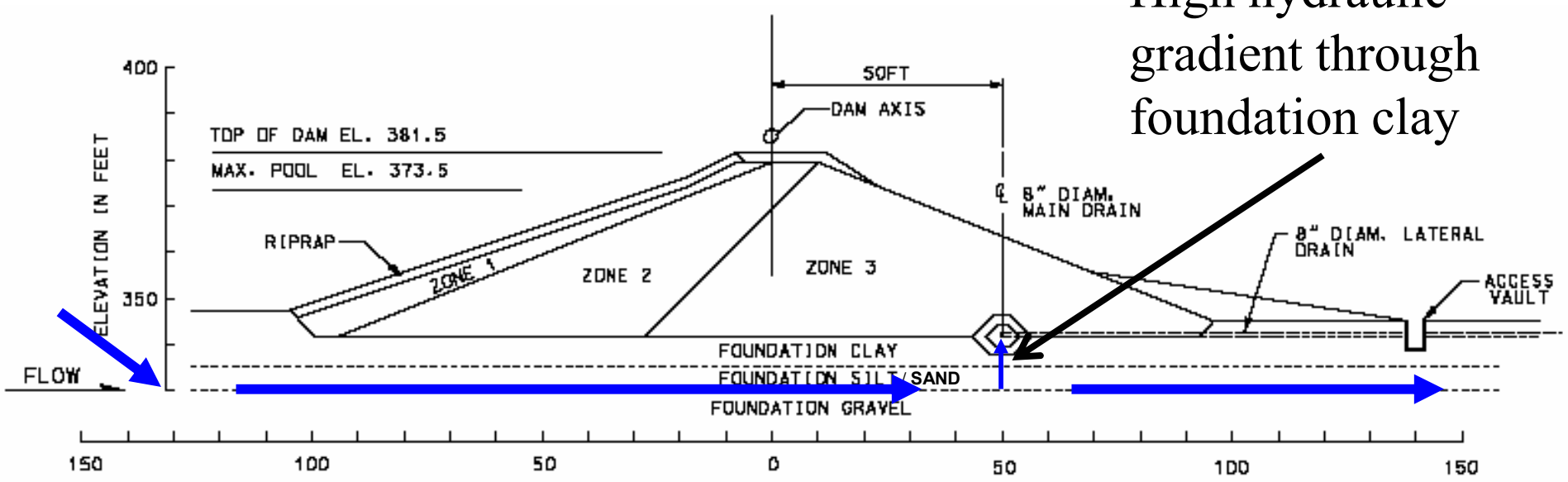


Original design flow net drawn by Cedergren in 1940



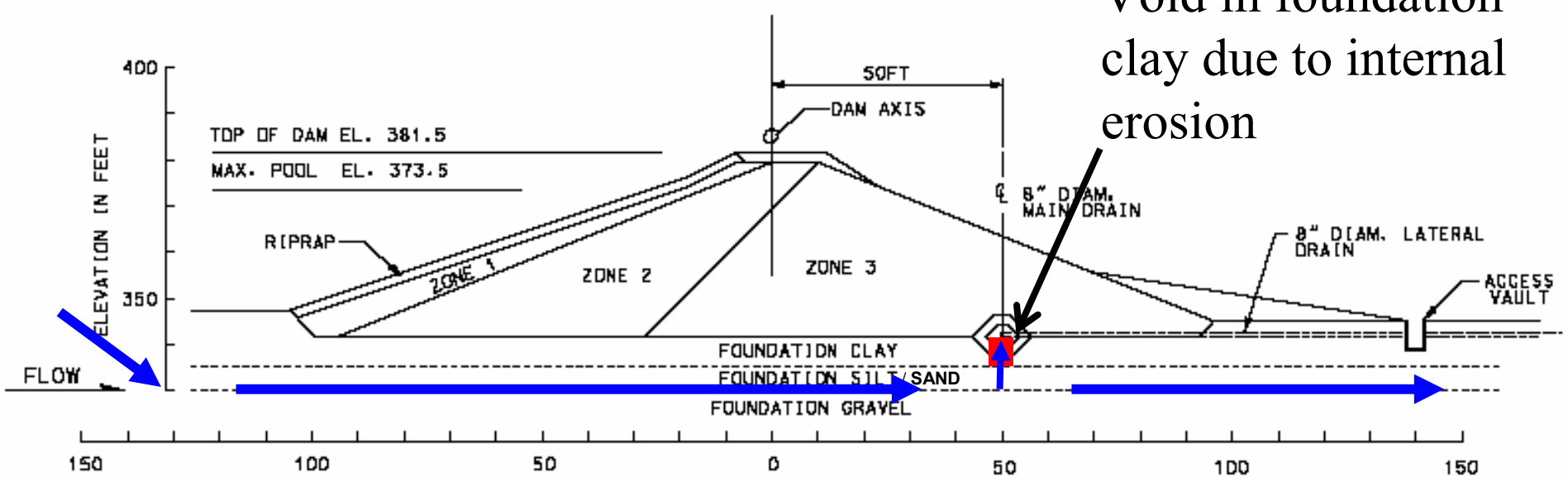
FEM seepage analysis of existing conditions: i ≈ 1 at toe of disposal zone

Piping in Foundation Silty Sand

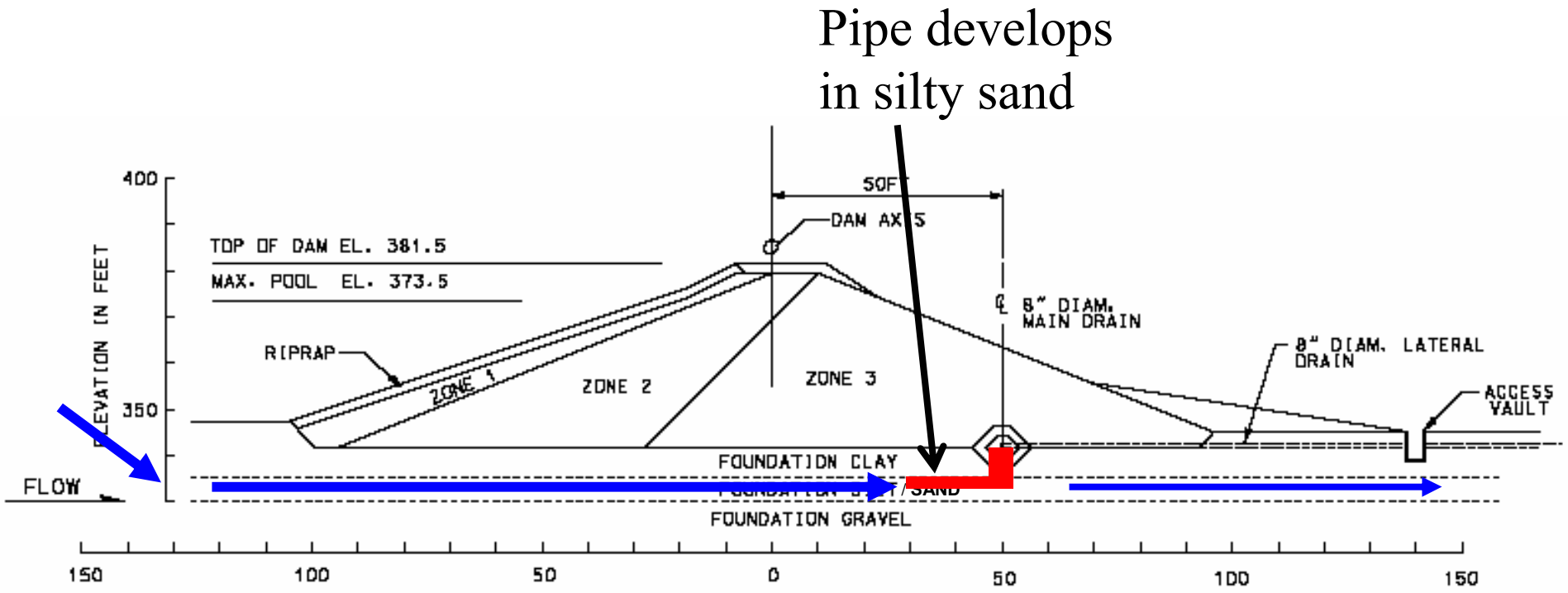


Foundation seepage to Kirk Pond

Piping in Foundation Silty Sand

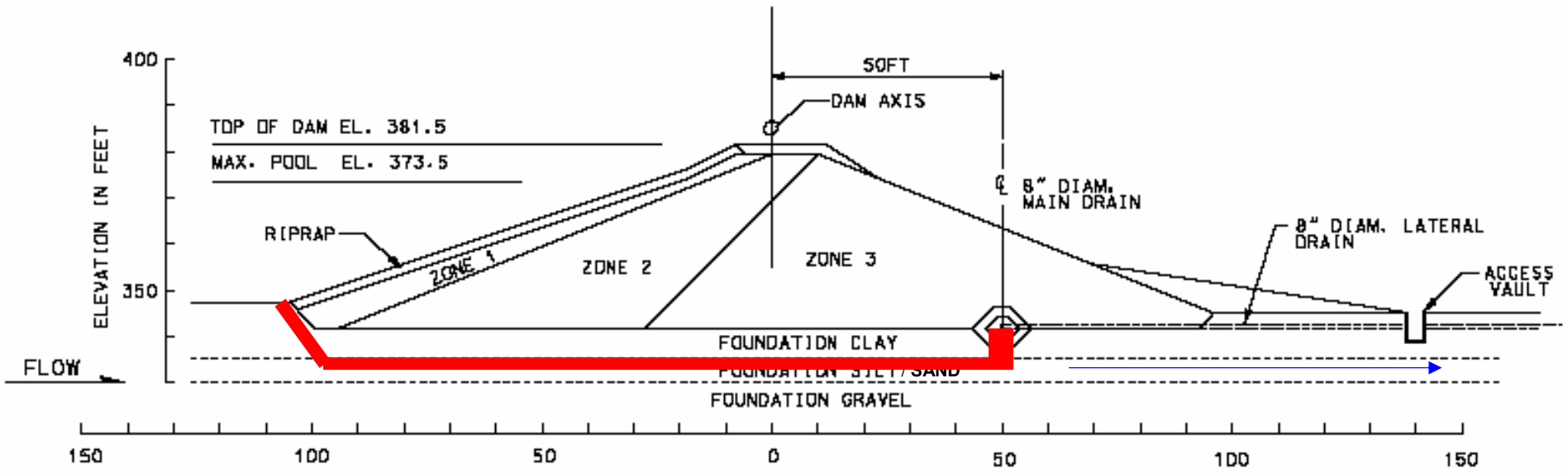


Piping in Foundation Silty Sand



Flow rate increases due
to shortening flow path

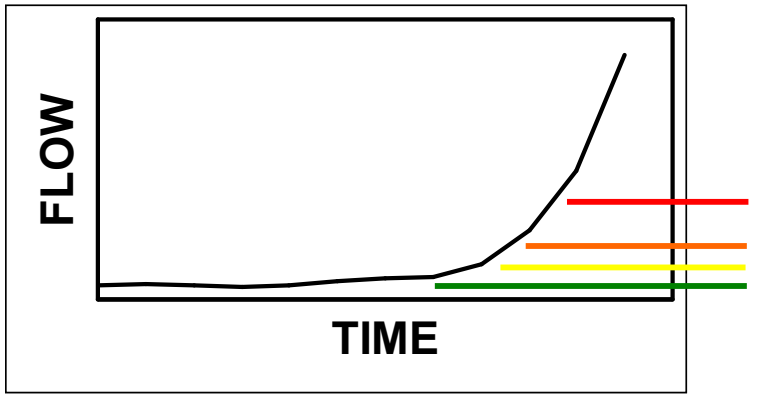
Piping in Foundation Silty Sand



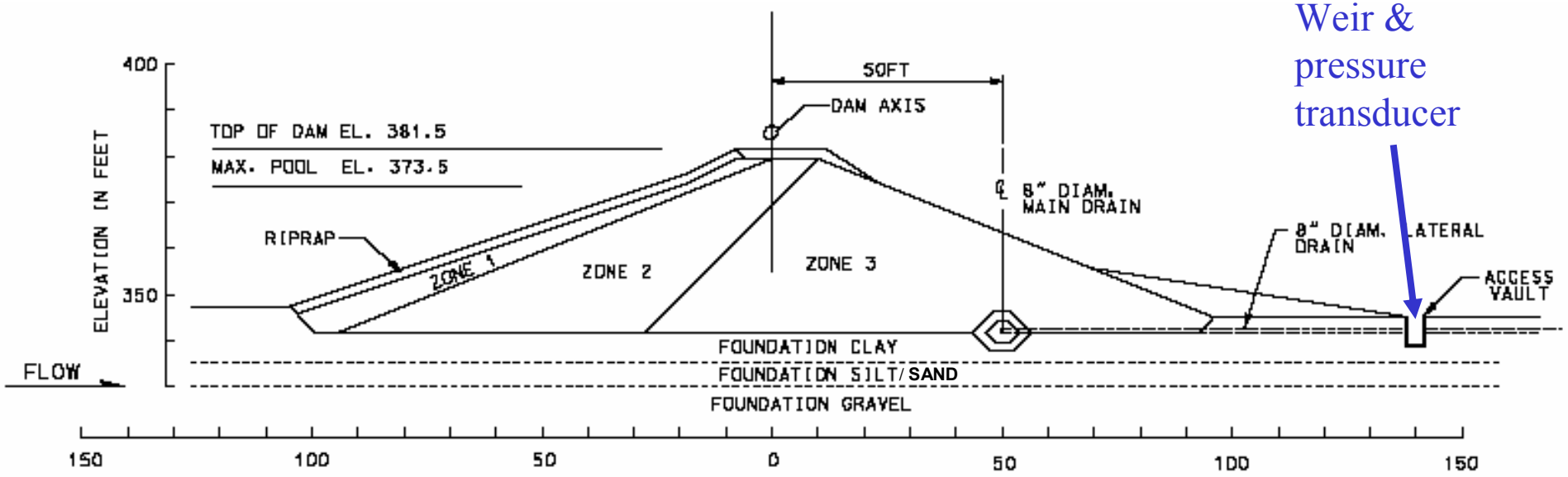
Pipe reaches lake. Flow rate and erosion accelerate rapidly

Event Alert System

* Lookout Point Control Room
* Fern Ridge Project
* Portland District Office



Weir & pressure transducer



Senior Review Board (12/04)

- Francke Walberg, URS (retired from Corps)
- Jim Talbot, retired from SCS
- Keith Ferguson, Kleinfelder

➢ "Active state of failure by piping and/or internal erosion"

➢ "District's focus should be immediately shifted from investigations and evaluation to development and implementation of corrective actions"

Station 14+40

At Pool Elev 373.5 (Max. Cons. Pool)

For Foundation Piping/Erosion FM

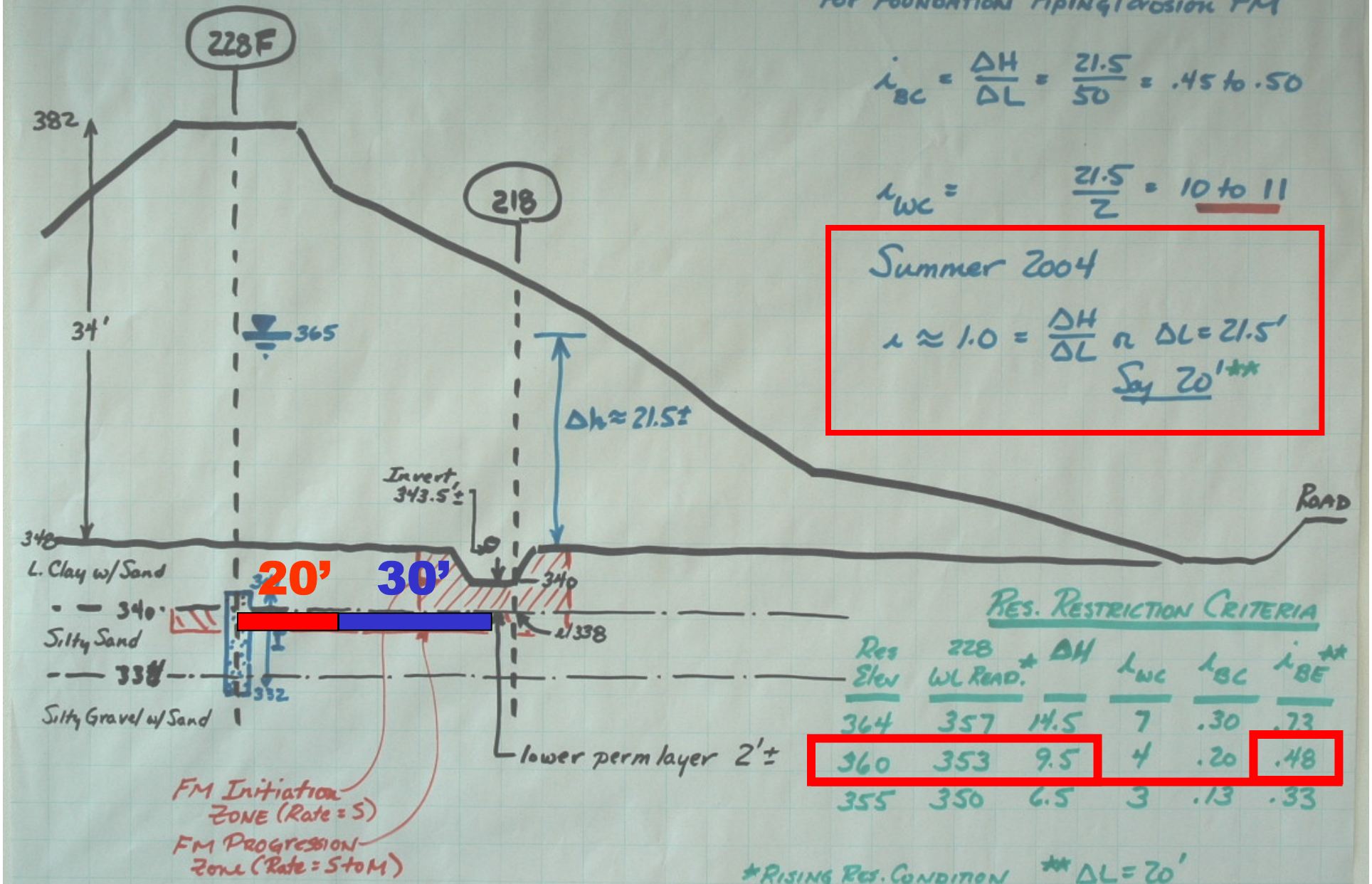
$i_{BC} = \frac{\Delta H}{\Delta L} = \frac{21.5}{50} = .45$ to $.50$

$i_{WC} = \frac{21.5}{2} = 10$ to 11

Summer 2004

$i \approx 1.0 = \frac{\Delta H}{\Delta L}$ n $\Delta L = 21.5'$

Say $20'$ **



Res. Restriction Criteria

Res Elev	228 WL Read.*	ΔH	i_{WC}	i_{BC}	i_{BE}**
364	357	14.5	7	.30	.73
360	353	9.5	4	.20	.48
355	350	6.5	3	.13	.33

*Rising Res. Condition ** $\Delta L = 20'$

PROJECT BENEFITS

Flood Control

- $400M in damages prevented over 60 years
- $80M in 1996 flood
- Over $40M in 1997 and 1999 floods

Irrigation (Annual Benefit)

- Direct: $165k (water service contracts)
- Indirect: $1.5M to $2.9M (agricultural products)

PROJECT BENEFITS

Recreation (Sailing, Marinas, Campgrounds)

- 600,000 visitors per year
- $5M in local benefits, $3.5M in indirect benefits

Environmental

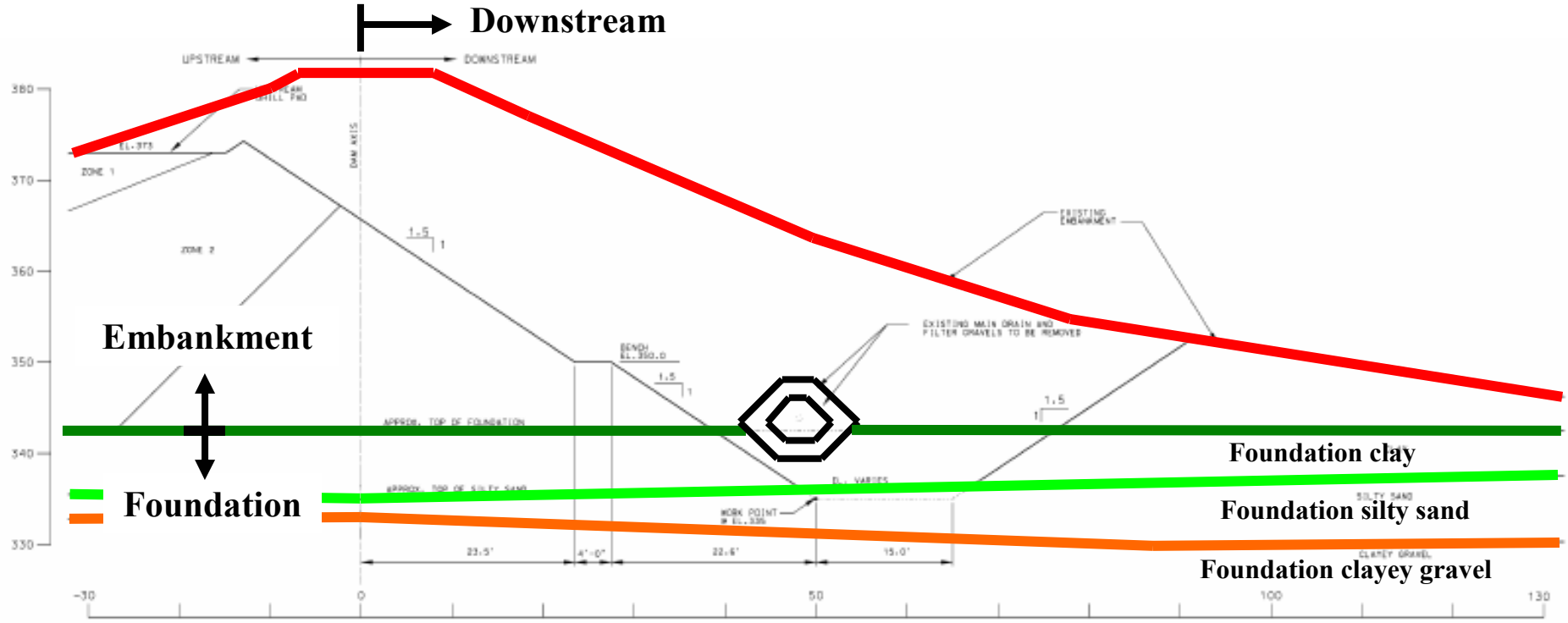
- Sect. 1135 restoration projects, Waterfowl nesting habitat, Warm water fisheries, Shoreline riparian habitat

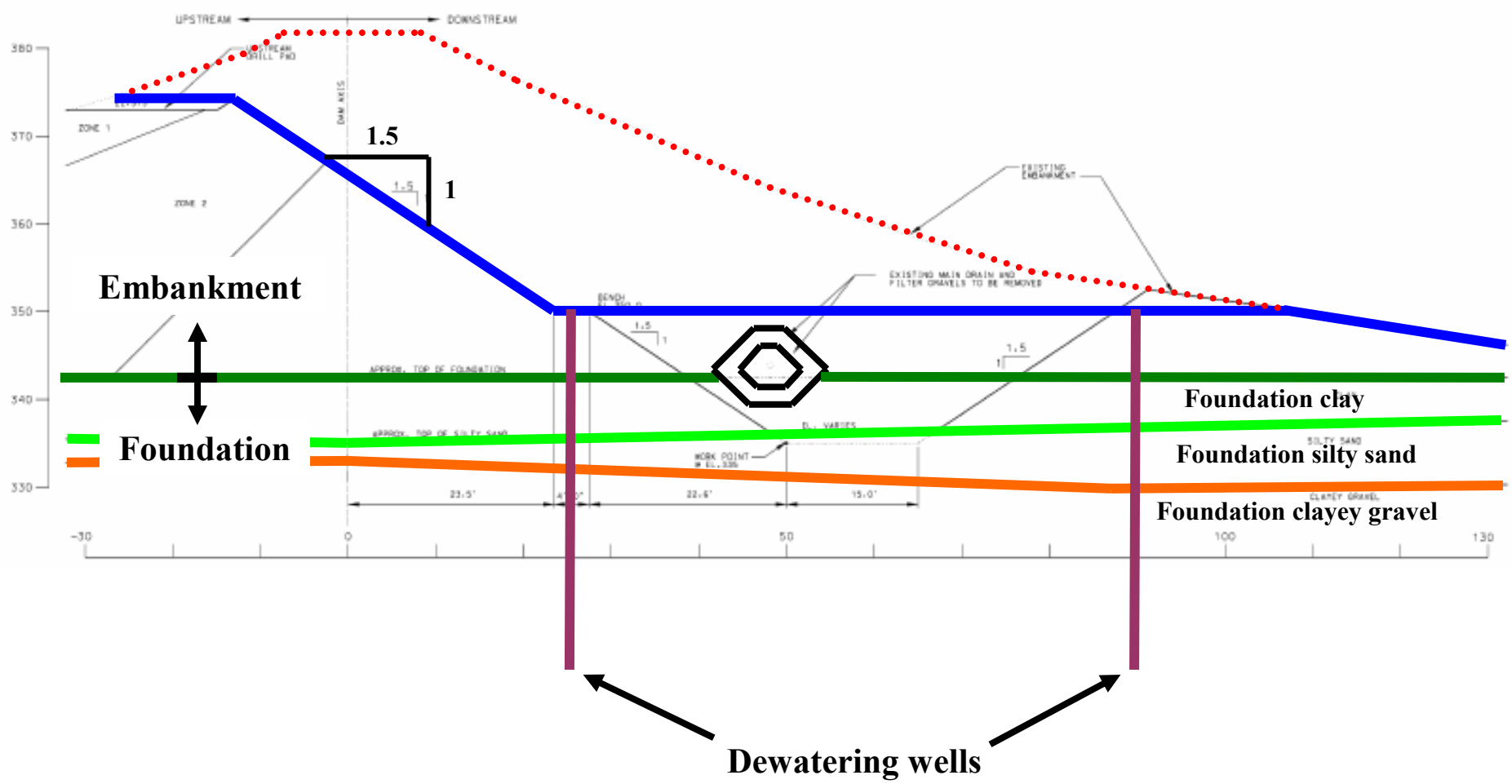
SCHEDULE

• Senior review board	Dec	2004
• Decision to repair	Feb 10,	2005
• Awarded contract	May 13,	2005
• Construction began	June 1,	2005
• Complete main construction	Oct 15,	2005
• Be ready for flood control season	Nov 1,	2005

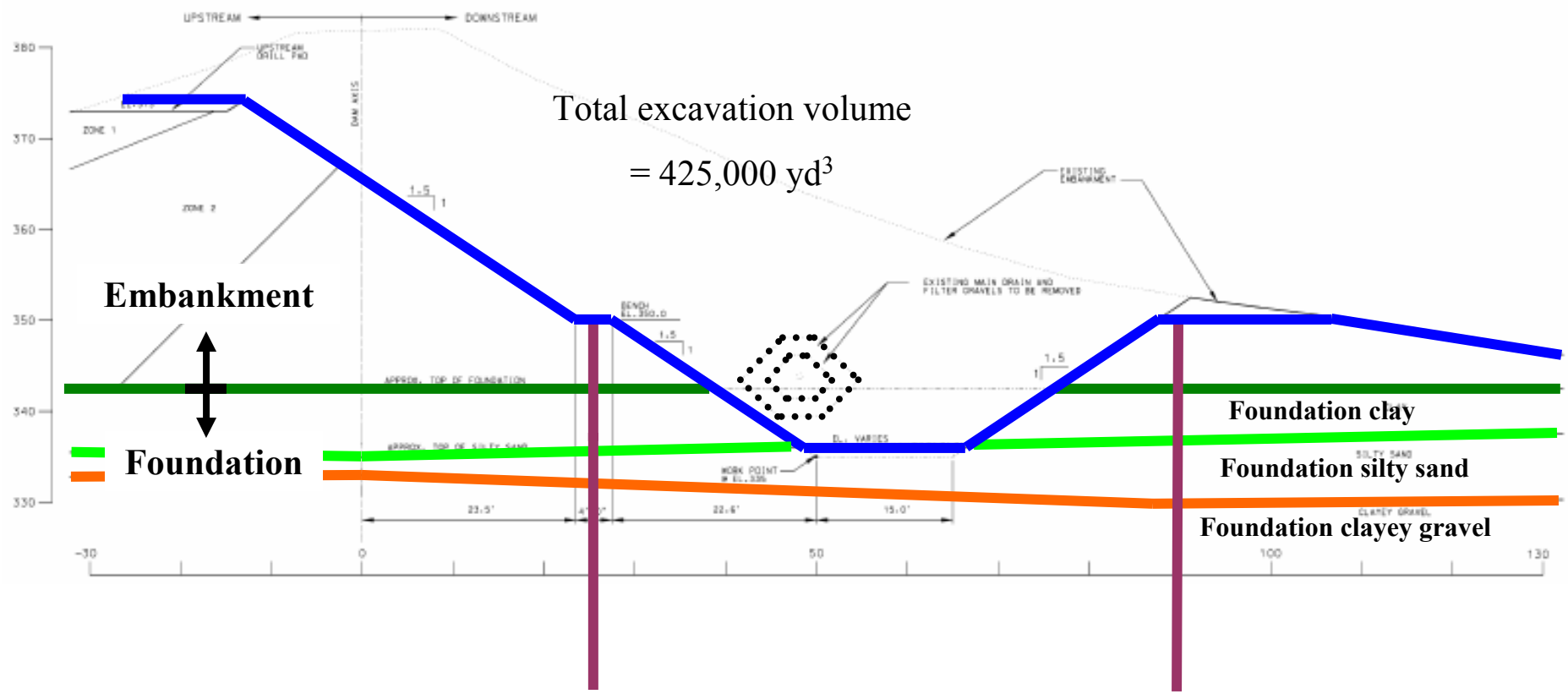
Design Goals

- Constructible in 5 – 6 months
- Remove failing drainage system and repair any small voids/erosion channels (if we have to repair large features, construction will exceed 6 months)
- New drain: collect embankment and foundation seepage
- Leave room for a potential seismic repair

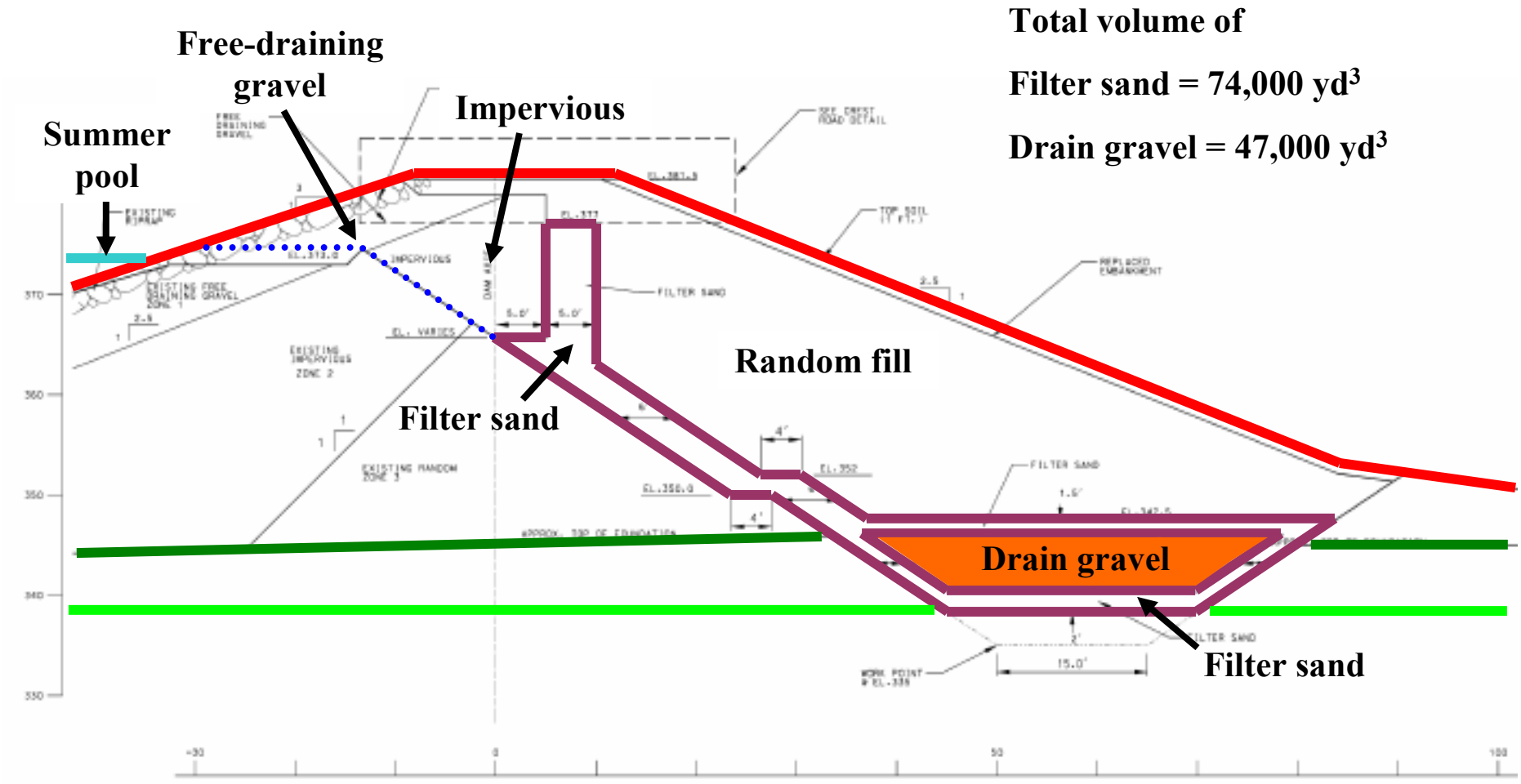

Downstream
UPSTREAM
DOWNSTREAM
Embankment
Foundation
Foundation clay
Foundation silty sand
Foundation clayey gravel
380
370
360
350
340
330
-30
0
50
100
130


UPSTREAM
DOWNSTREAM
1.5
1
Embankment
Foundation
Foundation clay
Foundation silty sand
Foundation clayey gravel
Dewatering wells


CAT


Total excavation volume
= 425,000 yd3
Embankment
Foundation
Foundation clay
Foundation silty sand
Foundation clayey gravel
UPSTREAM
DOWNSTREAM
APPROX. TOP OF FOUNDATION
EXISTING MAIN DRAIN AND FILTER GRAVELS TO BE REMOVED
WORK POINT


CAT
CAT 349D


Free-draining gravel
Impervious
Summer pool
Total volume of
Filter sand = 74,000 yd3
Drain gravel = 47,000 yd3
Random fill
Filter sand
Drain gravel
Filter sand