

APPENDIX F

Slug Testing & Water Flow Balance Estimates

Appendix F: Slug Testing and Water Flow Balance Estimates

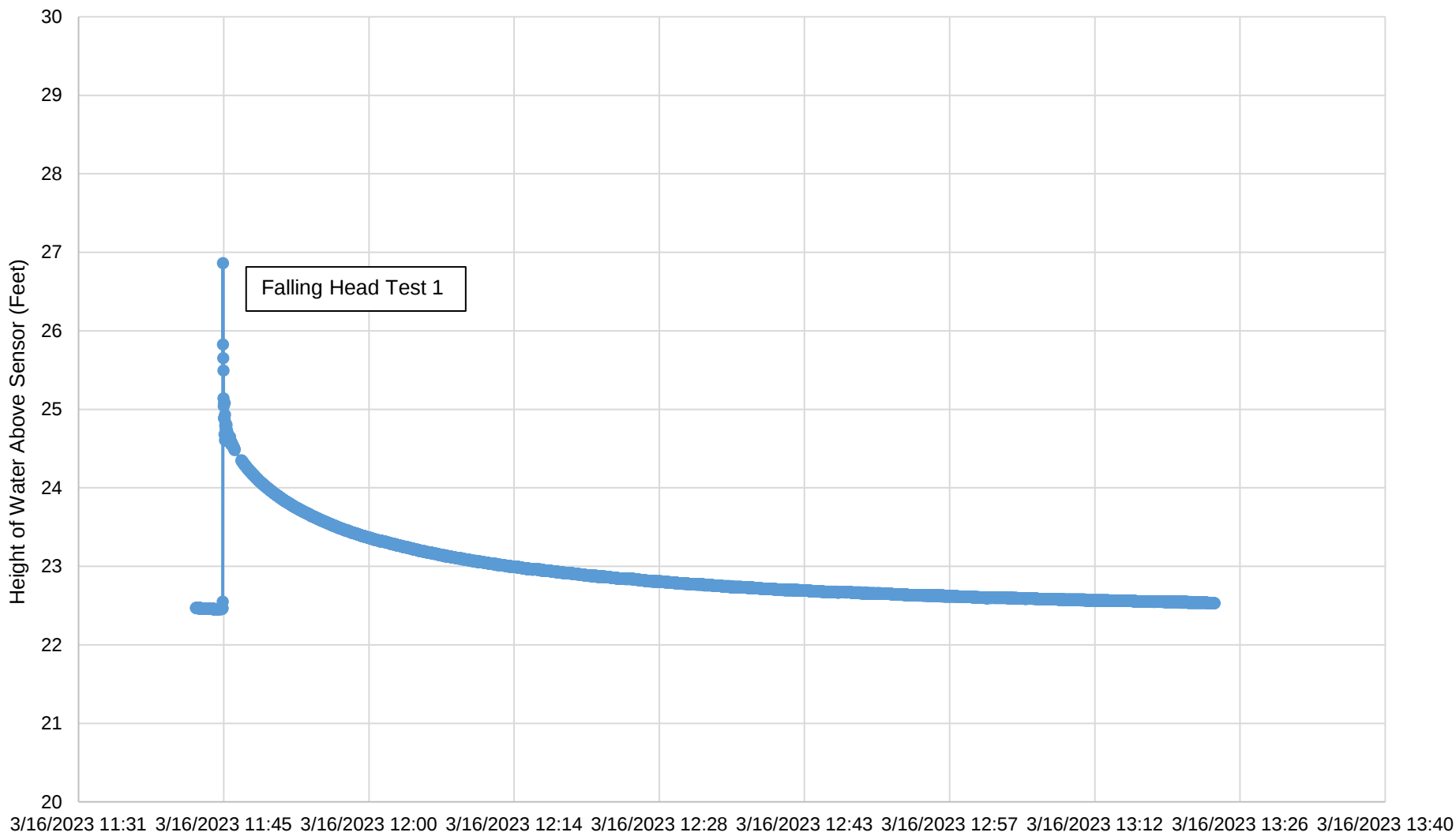
Appendix F presents slug testing results for select monitoring wells on the Preliminary Site. The appendix also presents the water flow calculations and the specific capacity calculations for monitoring wells P-16 and B-15.

Appendix F.1: Slug Testing Hydrograph

Appendix F.2: Summary of Dimensions for each Cross-section, P-16 and Infiltration Trench

Appendix F.3: Specific Capacities

Appendix F.1: Slug Testing Hydrograph



LEGEND

CLIENT
HOLCIM (US) INC

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

CONSULTANT



YYYY-MM-DD 6/24/2023

DESIGNED MPK

PREPARED GLK

REVIEWED MLK

APPROVED GZ

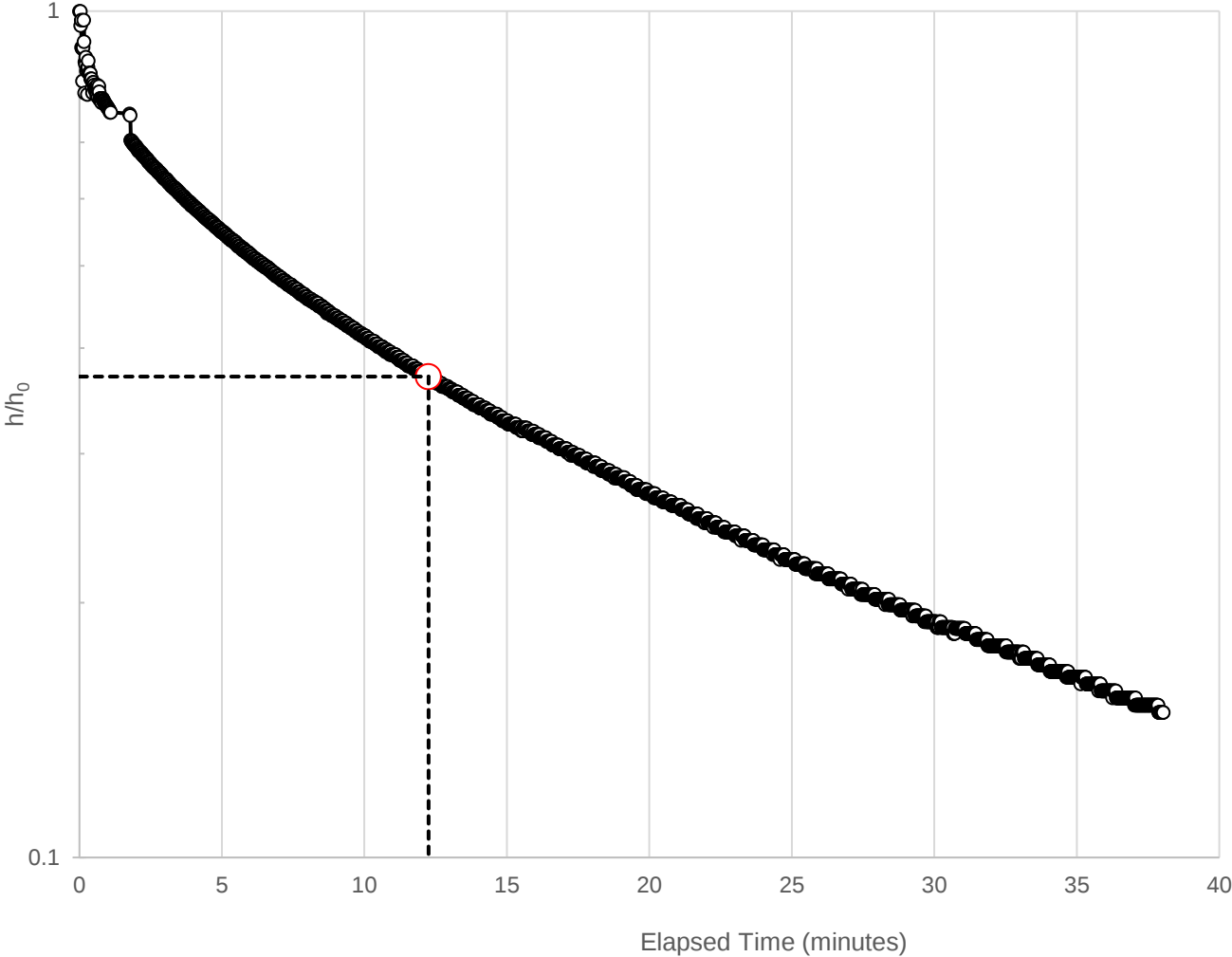
TITLE
B-15
SLUG TEST HYDROGRAPH

PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.1



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t_{37} - time when $h/h_0 = 0.37$
- h - displaced head
- h_0 - initial displaced head

Falling-Head Test Analysis:

$K = 9.8 \cdot 10^{-5}$ feet/minute

LEGEND

○ B-15 ○ t37

CLIENT
HOLCIM (US) INC

CONSULTANT



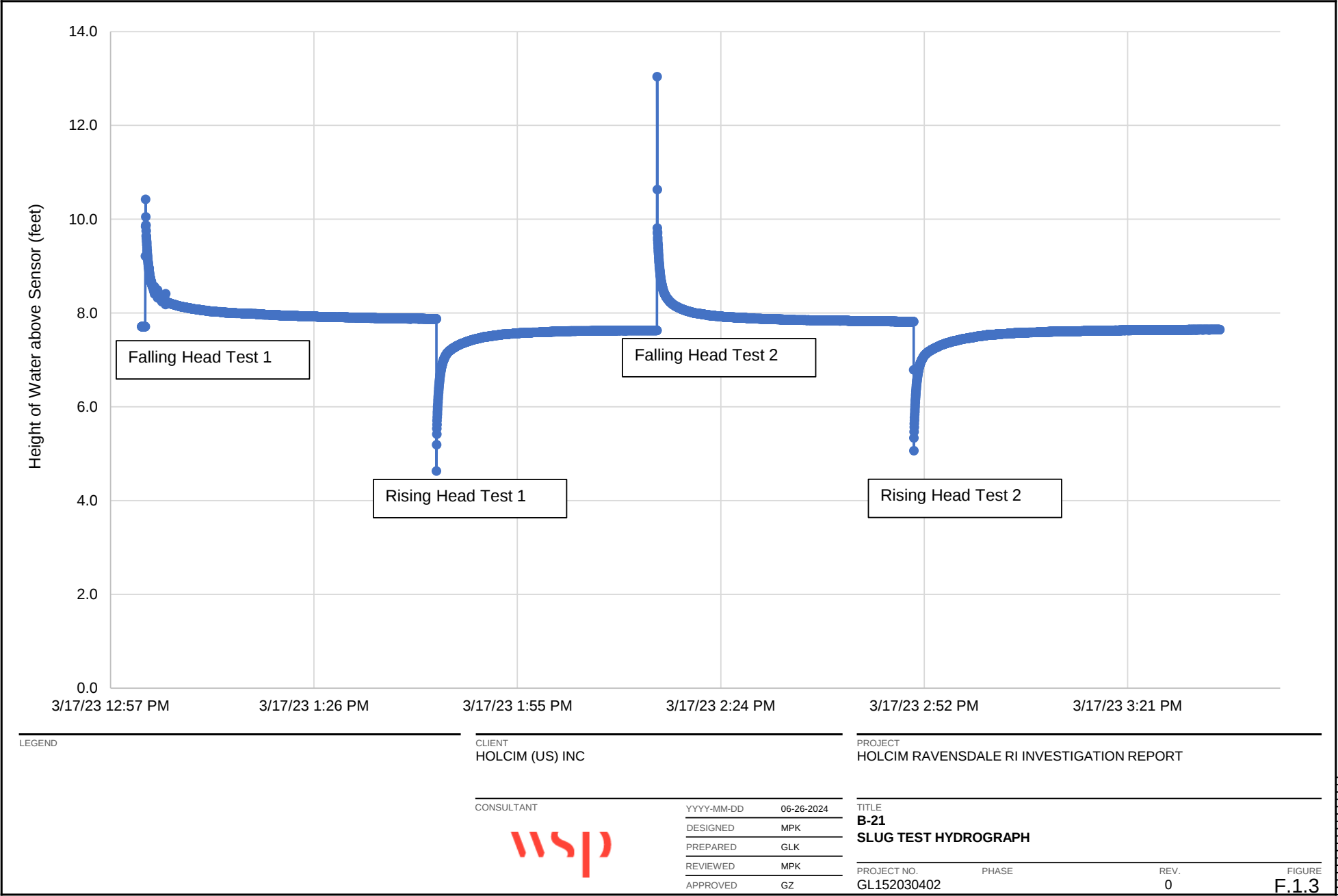
YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

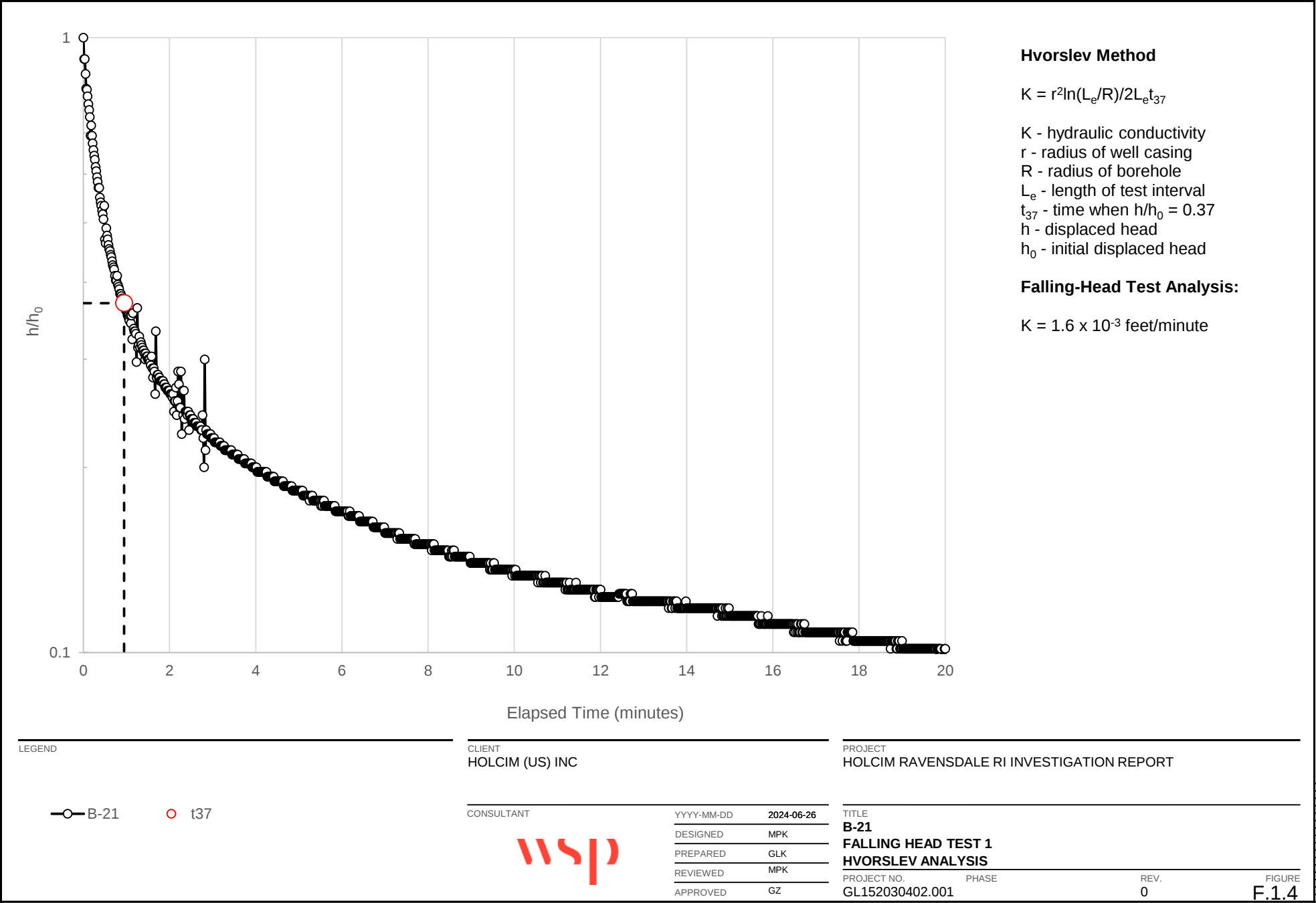
PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
B-15
FALLING HEAD TEST 1
HVORSLEV ANALYSIS

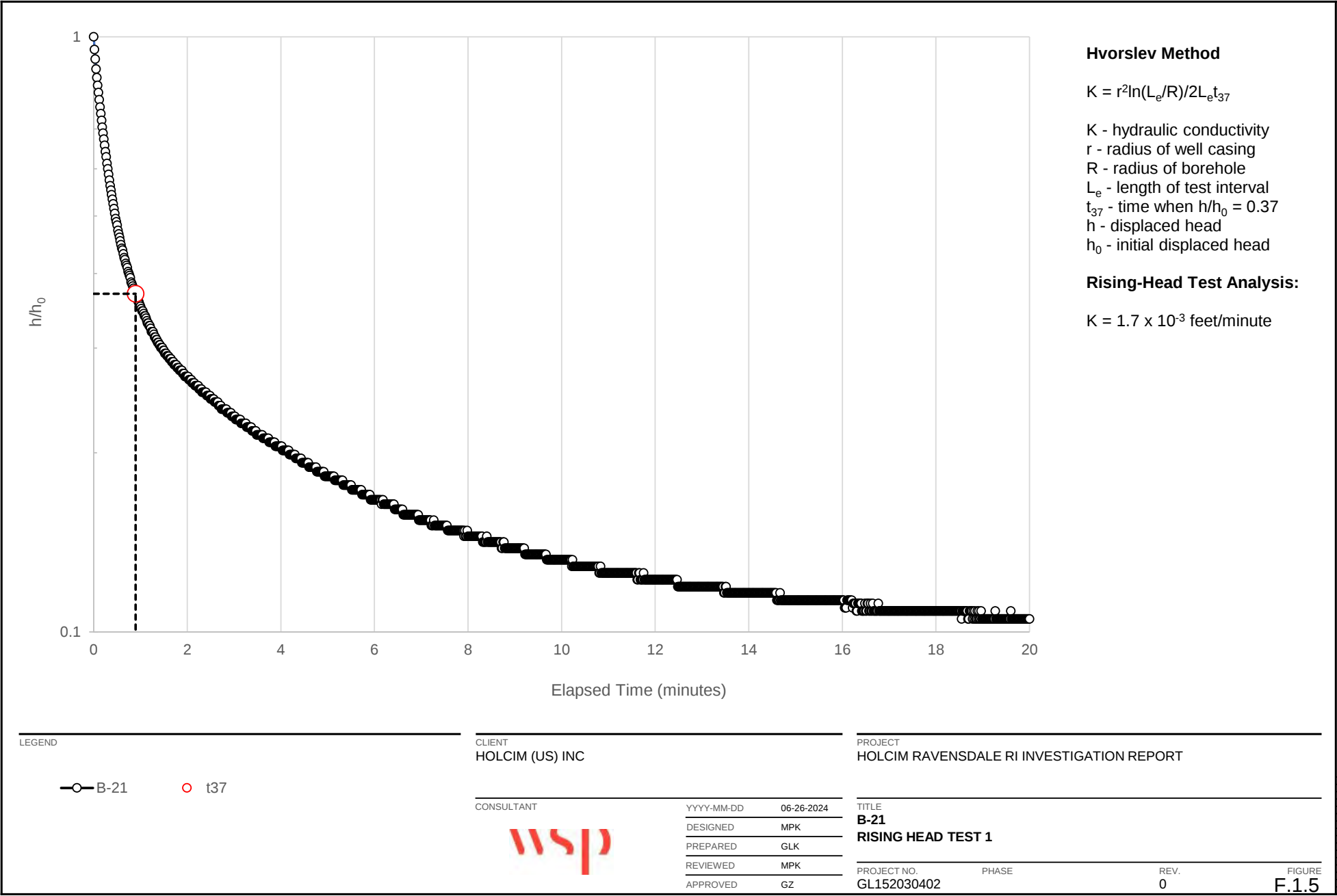
PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.2

PATH: https://wspnlinenam.sharepoint.com/Sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/USE THESE FOR REPORT/Data | FILE NAME: B-21_Hvorslev.xlsx

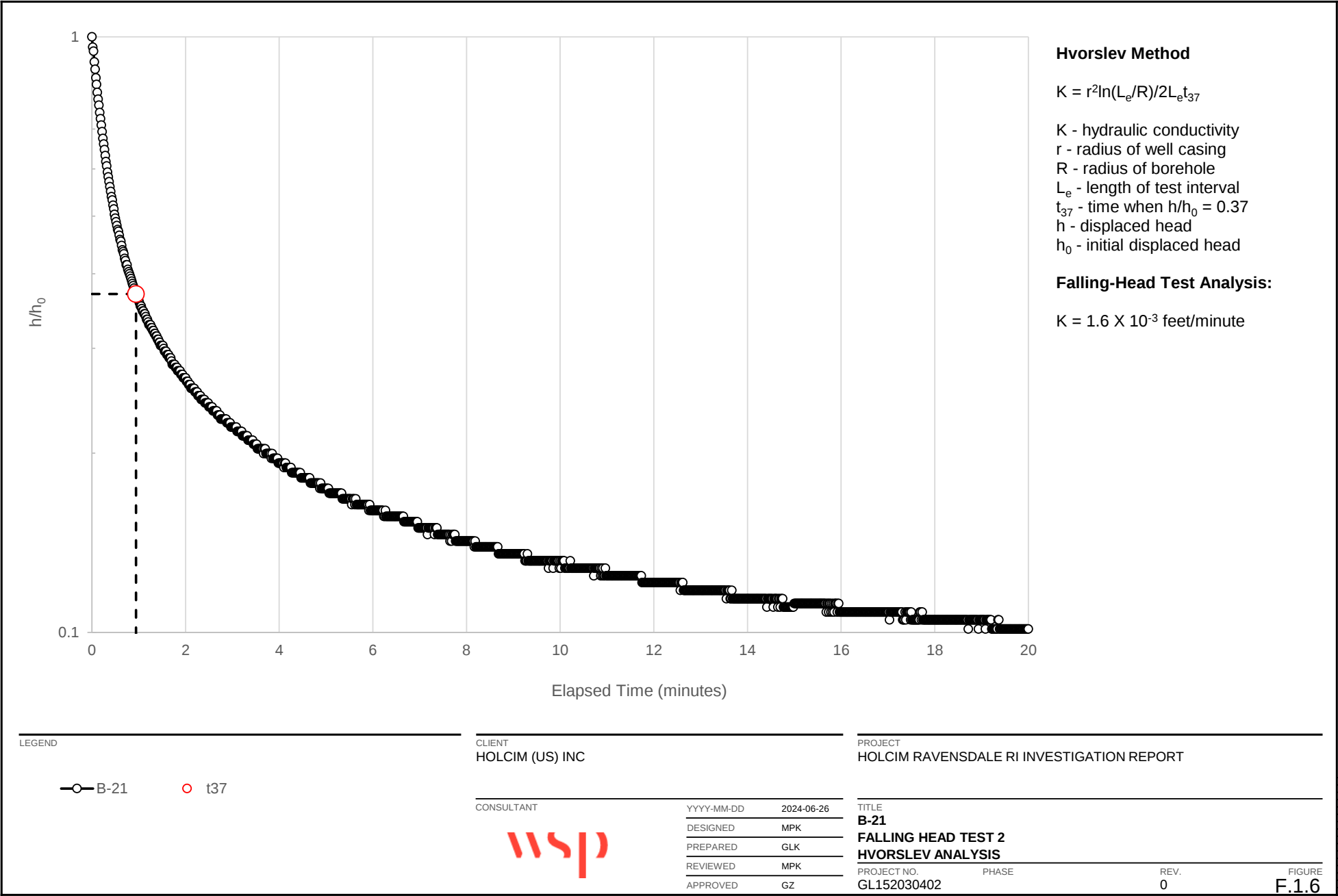




PATH: https://wsponline.nam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/USE THESE FOR REPORT/Data | FILE NAME: B-21_Hvorslev.xlsx

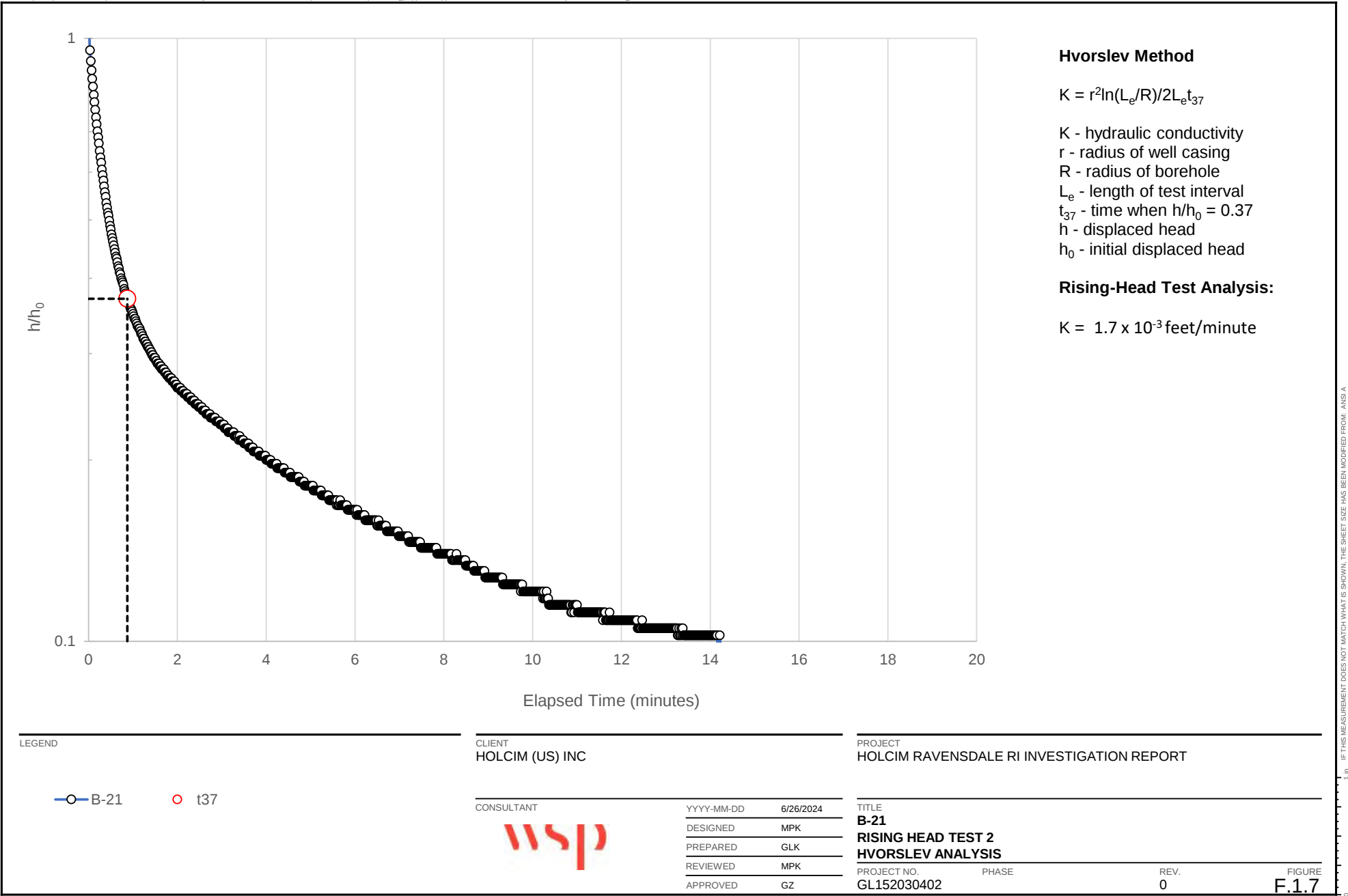


PATH: https://wsponlineinam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/USE THESE FOR REPORT/Data | FILE NAME: B-21_Hvorslev.xlsx



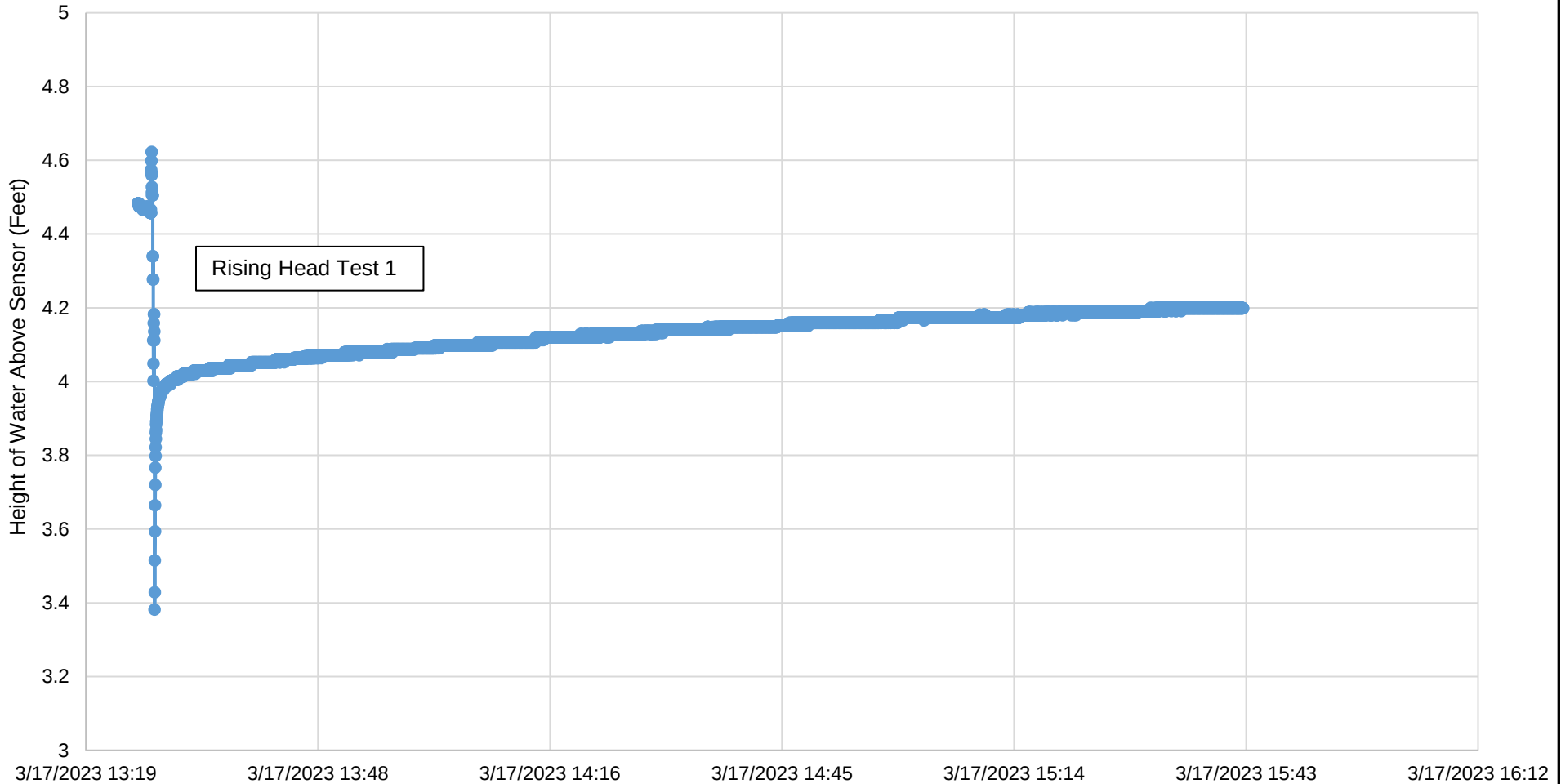
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

PATH: https://wsp.onlinenam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/USE THESE FOR REPORT/Data | FILE NAME: B-21_Hvorslev.xlsx



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

PATH: https://wspnline.nam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/USE THESE FOR REPORT/Data | FILE NAME: B-27_Hvorslev.xlsx



LEGEND

CLIENT
HOLCIM (US) INC

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

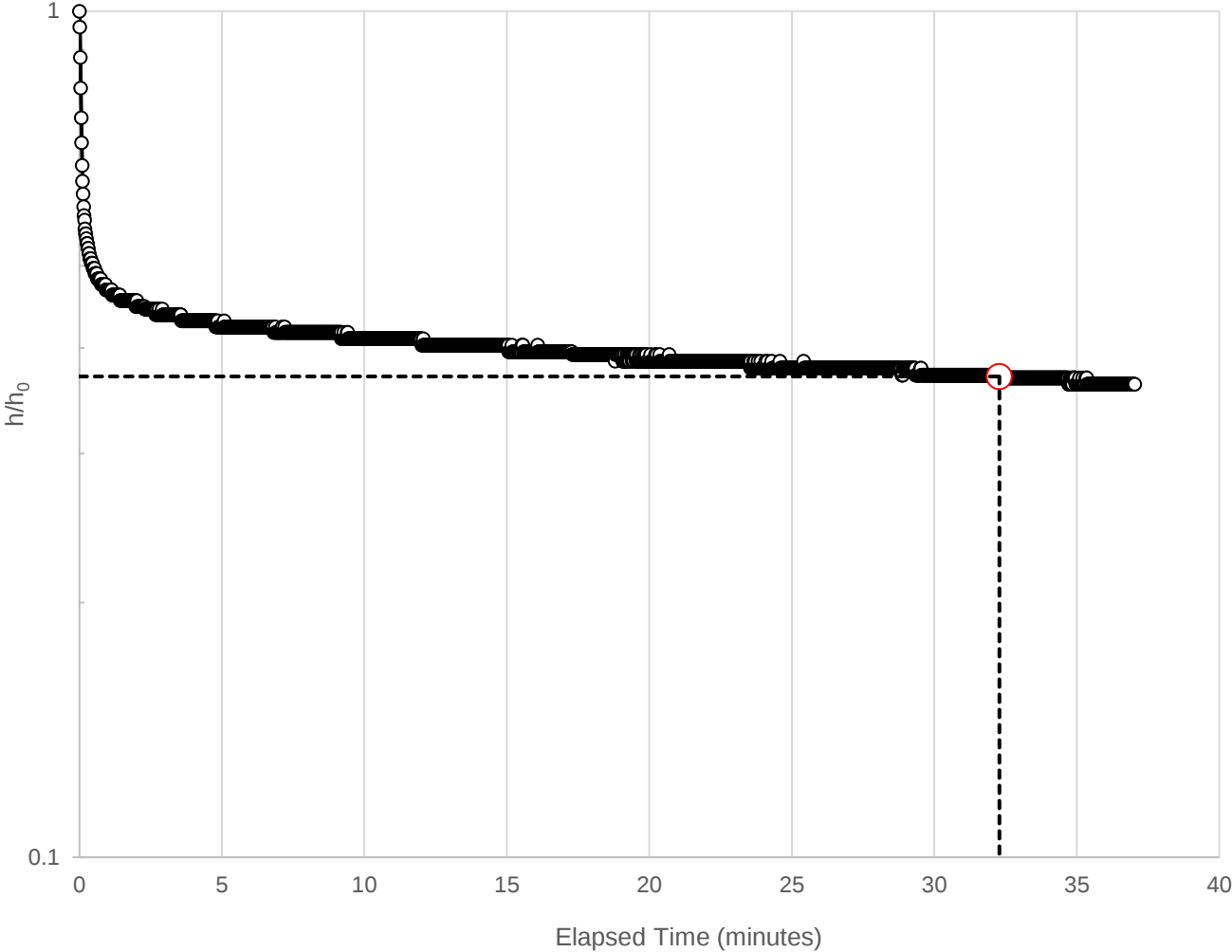
TITLE
B-27
SLUG TEST HYDROGRAPH

PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.8



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t₃₇ - time when h/h₀ = 0.37
- h - displaced head
- h₀ - initial displaced head

Rising-Head Test Analysis:

$K = 3.3 \times 10^{-5}$ feet/minute

LEGEND

○ B-27 ○ t₃₇

CLIENT
HOLCIM (US) INC

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

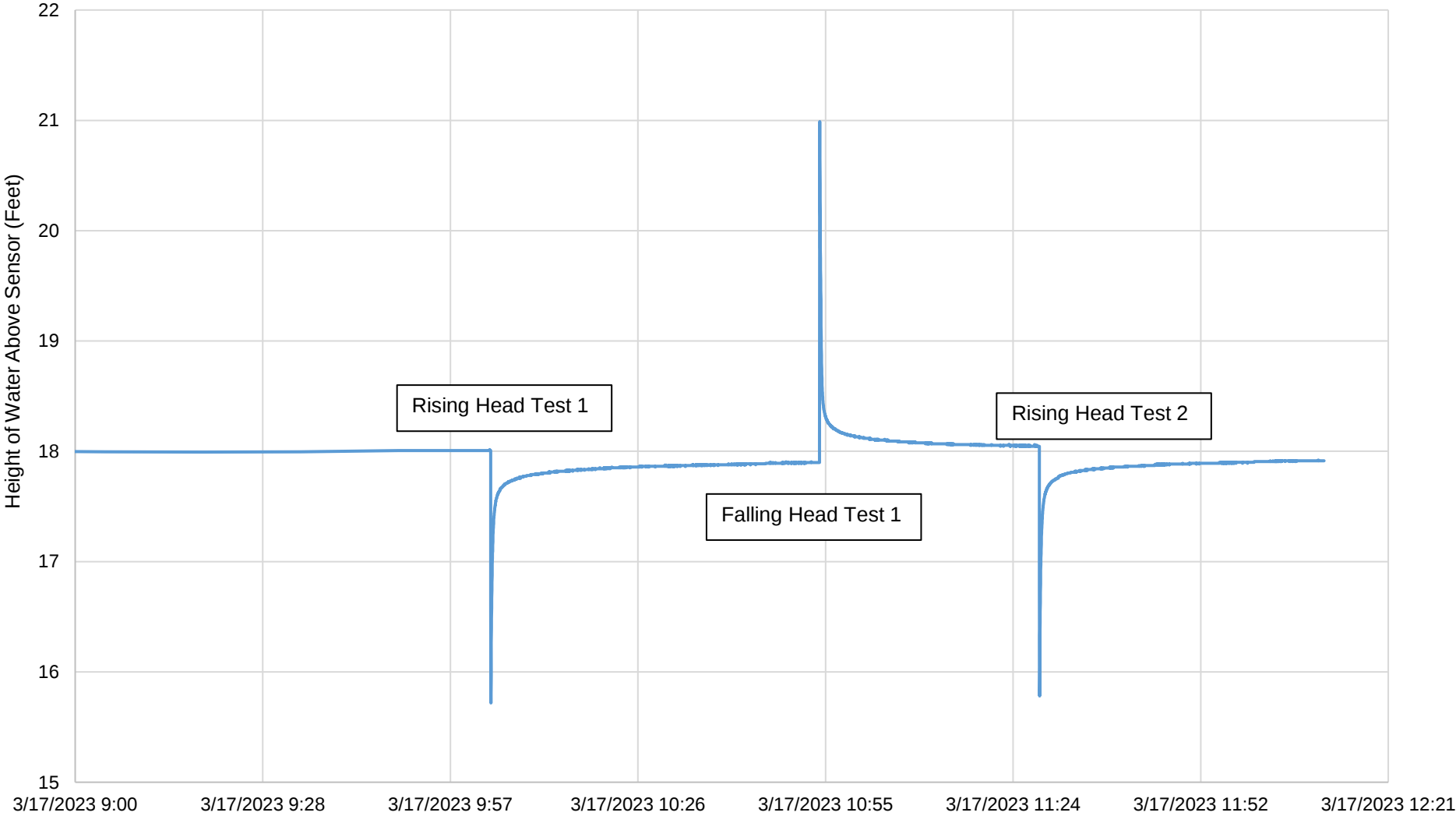
TITLE
B-27
RISING HEAD TEST 1
HVORSLEV ANALYSIS

PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.9



LEGEND

CLIENT
HOLCIM (US) INC

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

CONSULTANT



YYYY-MM-DD 2024-06-26

DESIGNED MPK

PREPARED GLK

REVIEWED MLK

APPROVED GZ

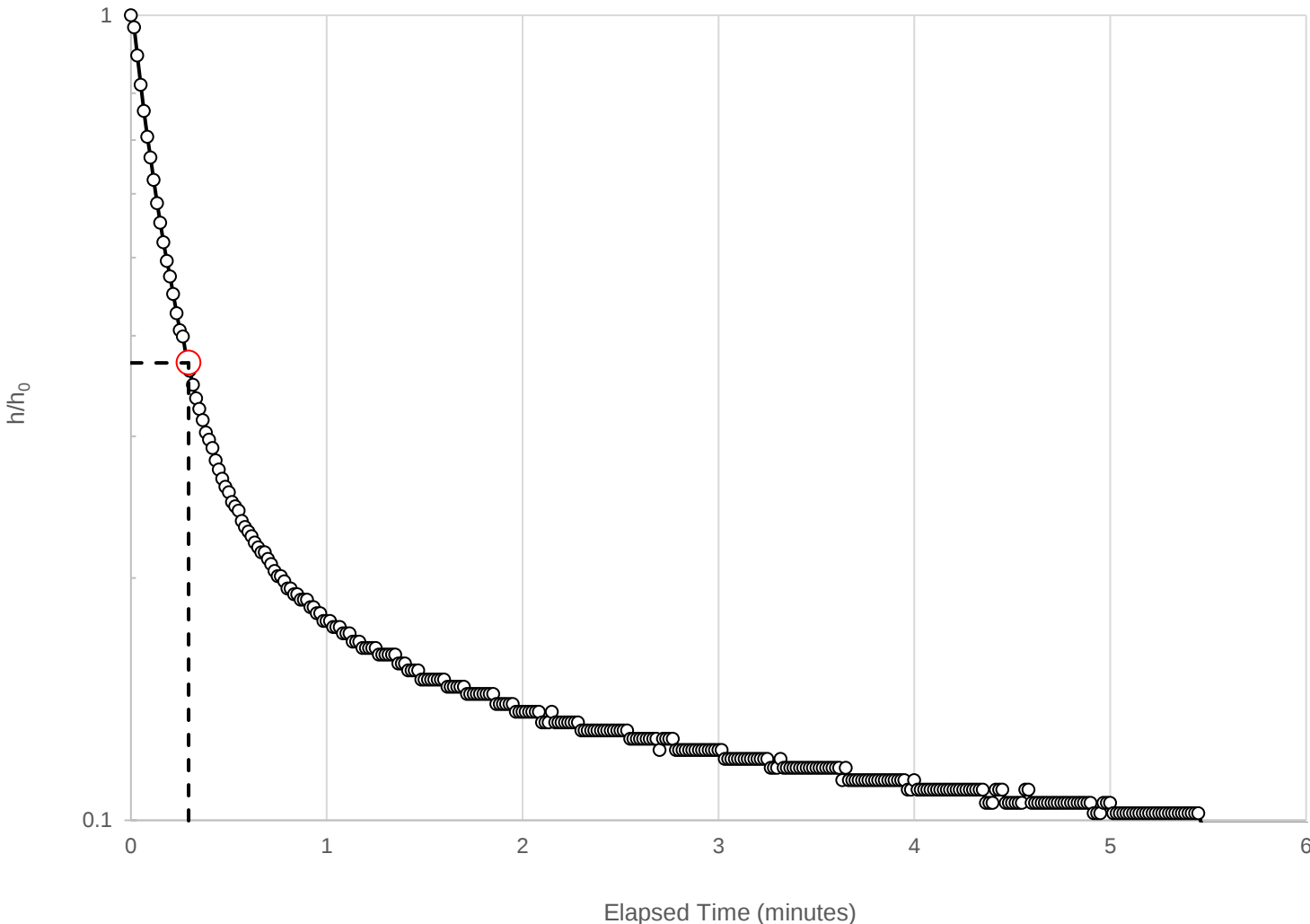
TITLE
**MWB-2LDA
SLUG TEST HYDROGRAPH**

PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.10



Hvorslev Method

$$K = r^2 \ln(L_e/R) / 2L_e t_{37}$$

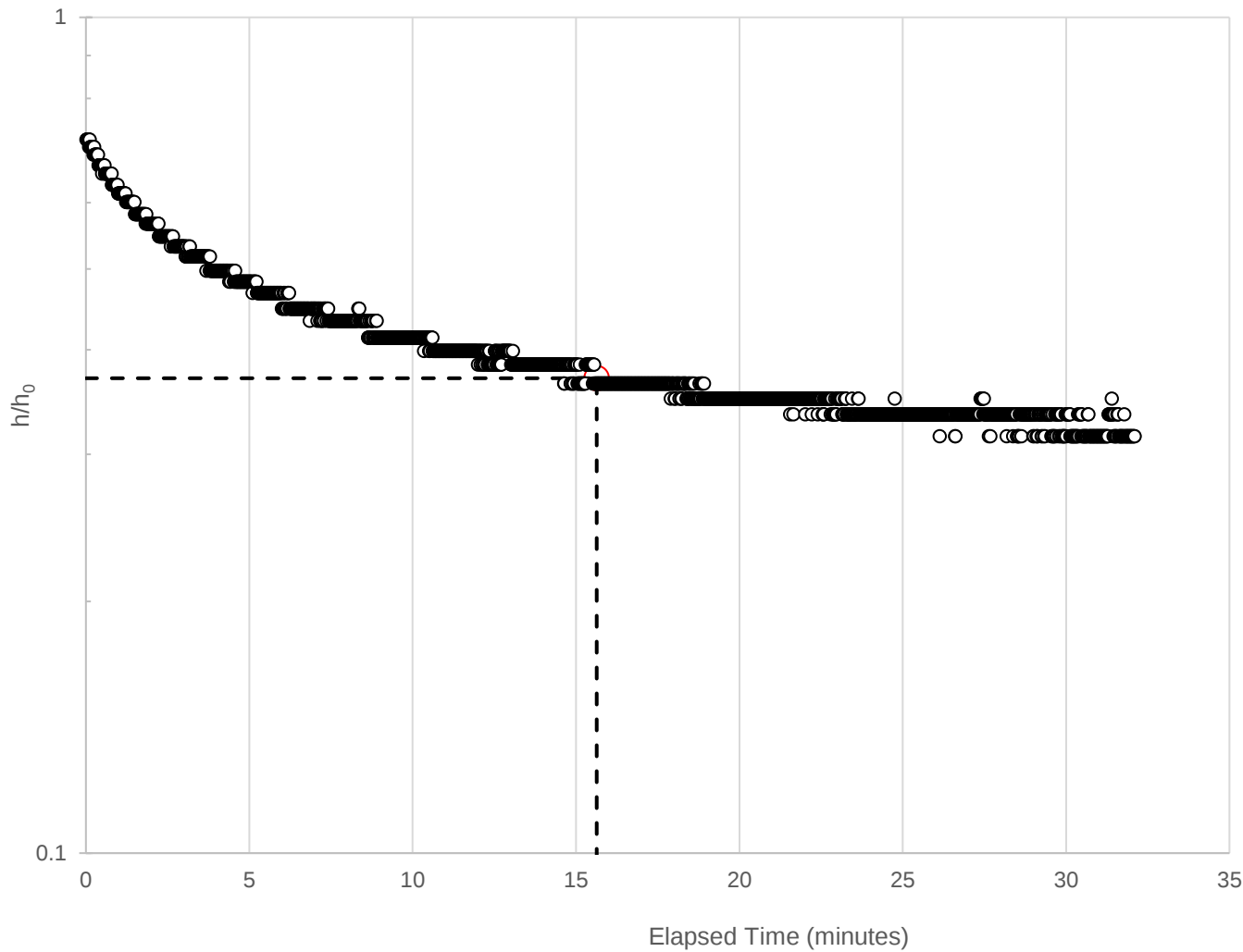
- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t_{37} - time when $h/h_0 = 0.37$
- h - displaced head
- h_0 - initial displaced head

Rising-Head Test Analysis:

$$K = 2.6 \times 10^{-3} \text{ feet/minute}$$

LEGEND	CLIENT HOLCIM (US) INC		PROJECT HOLCIM RAVENSDALE RI INVESTIGATION REPORT					
	CONSULTANT		TITLE					
		YYYY-MM-DD	2024-06-26	MWB-2LDA				
		DESIGNED	MPK	RISING HEAD TEST 1				
PREPARED		GLK	HVORSLEV ANALYSIS					
REVIEWED		MLK	PROJECT NO.	PHASE	REV.	FIGURE		
—○— MWB-2LDA	○ t37		APPROVED	GZ	GL152030402		0	F.1.11

1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

K - hydraulic conductivity

r - radius of well casing

R - radius of borehole

L_e - length of test interval

t₃₇ - time when h/h₀ = 0.37

h - displaced head

h₀ - initial displaced head

Falling-Head Test Analysis:

$K = 9.7 \times 10^{-3}$ feet/minute

LEGEND

○ MWB-2LDA ○ t₃₇

CLIENT
HOLCIM (US) INC



CONSULTANT	YYYY-MM-DD	6/26/2024
DESIGNED	MPK	
PREPARED	GLK	
REVIEWED	MLK	
APPROVED	GZ	

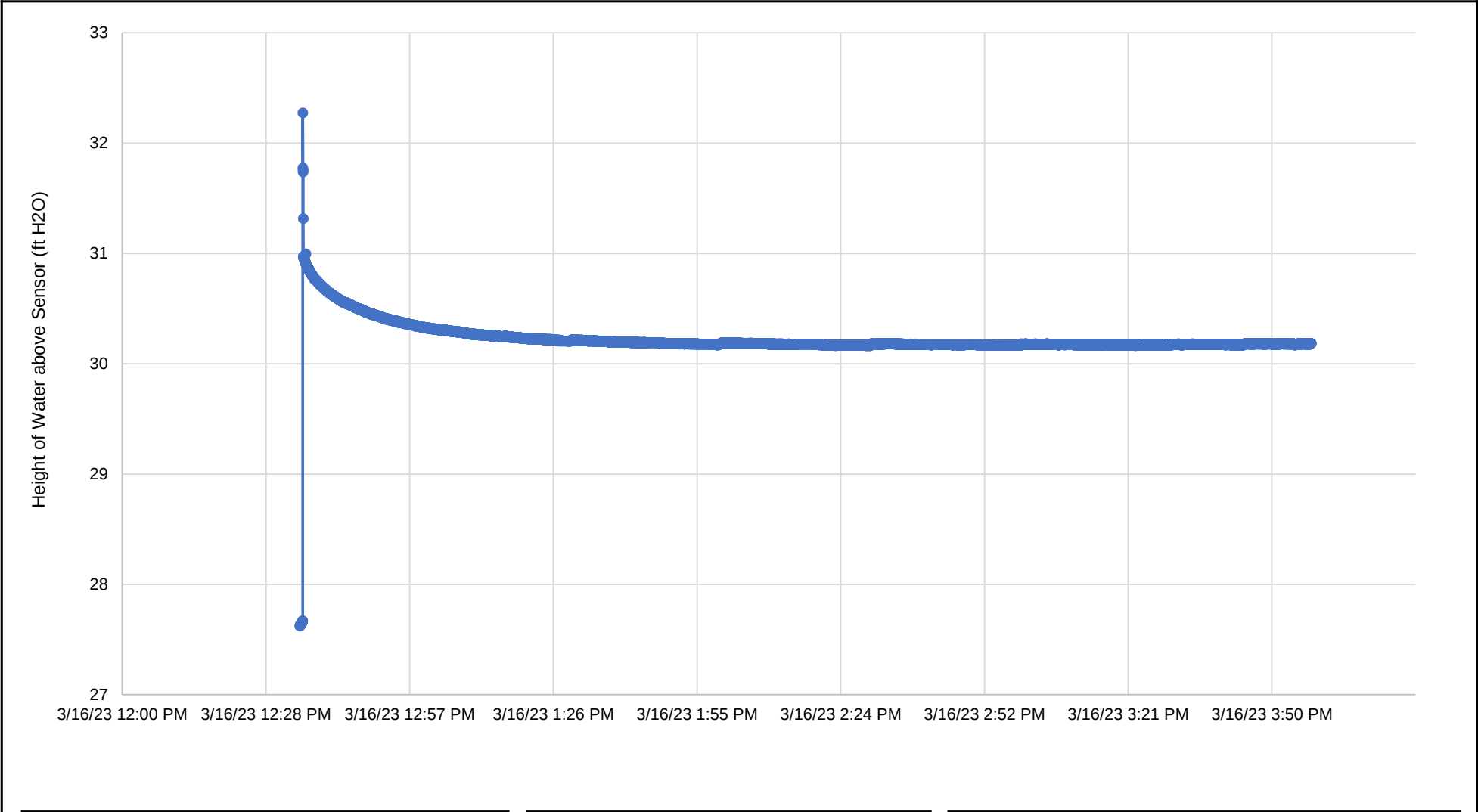
PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
MWB-2LDA
FALLING HEAD TEST 1
HVORSLEV ANALYSIS

PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.12

DRAFT

PATH: https://wsponline.nam.sharepoint.com/Sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/Slug Test Graphs USE THESE FOR REPORT/Data | FILE NAME: MWB-3LDA_Hvorslev.xlsx



LEGEND

Note: Slug test not analyzed due to inadequate recovery.

CLIENT
HOLCIM (US) INC

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MPK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

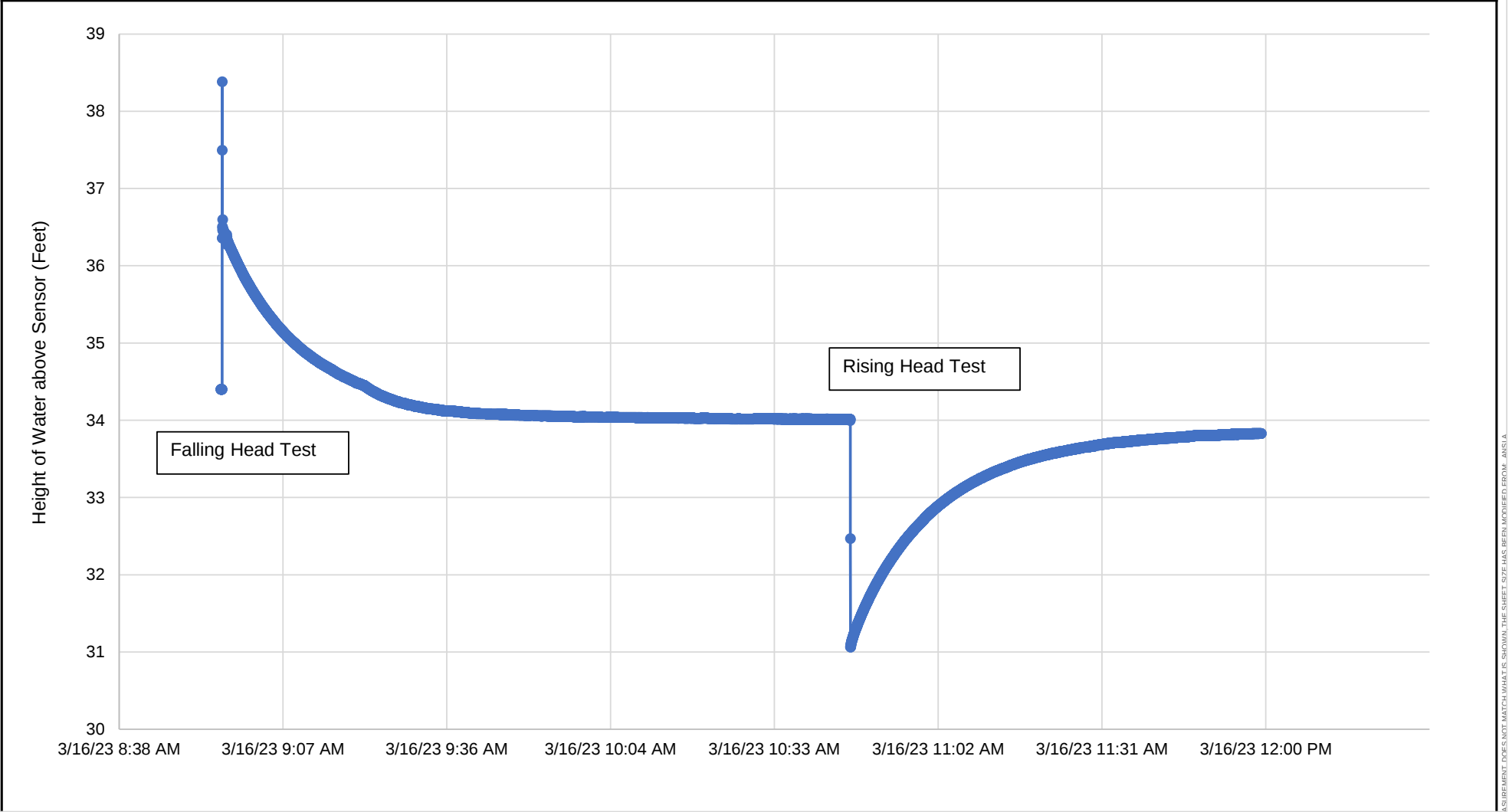
TITLE
MWB-3LDA
SLUG TEST HYDROGRAPH

PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

1 in

PATH: https://wsponline.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI_Report-Ecology/Appendix/Appx_D/Slug_Test_Graphs_USE_THESE_FOR_REPORT/Data | FILE NAME: P-13_Hvorslev.xlsx



LEGEND

CLIENT
HOLCIM (US) INC

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MPK
APPROVED	GZ

TITLE
P-13
SLUG TEST HYDROGRAPH

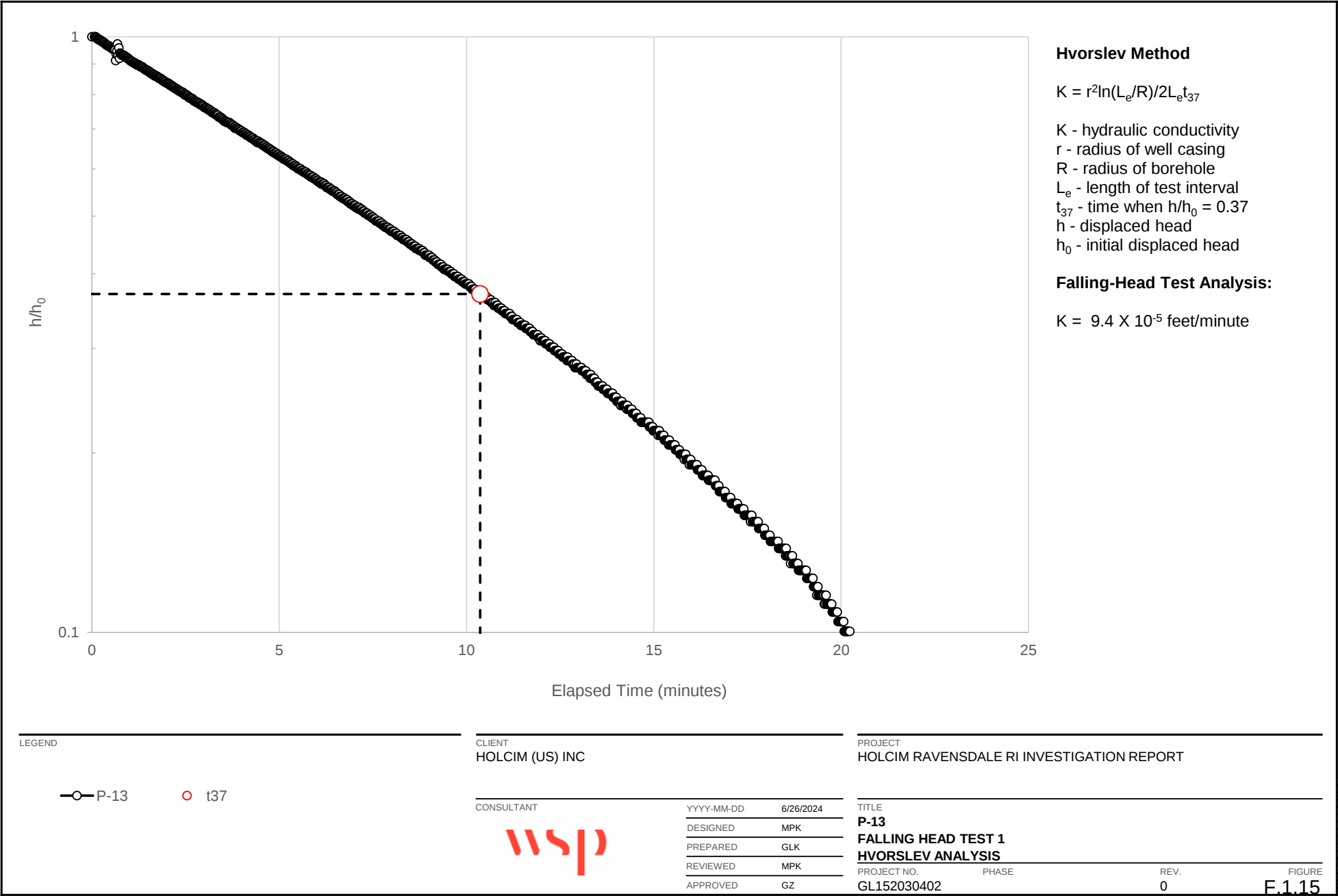
PROJECT NO.
GL152030402

PHASE

REV.

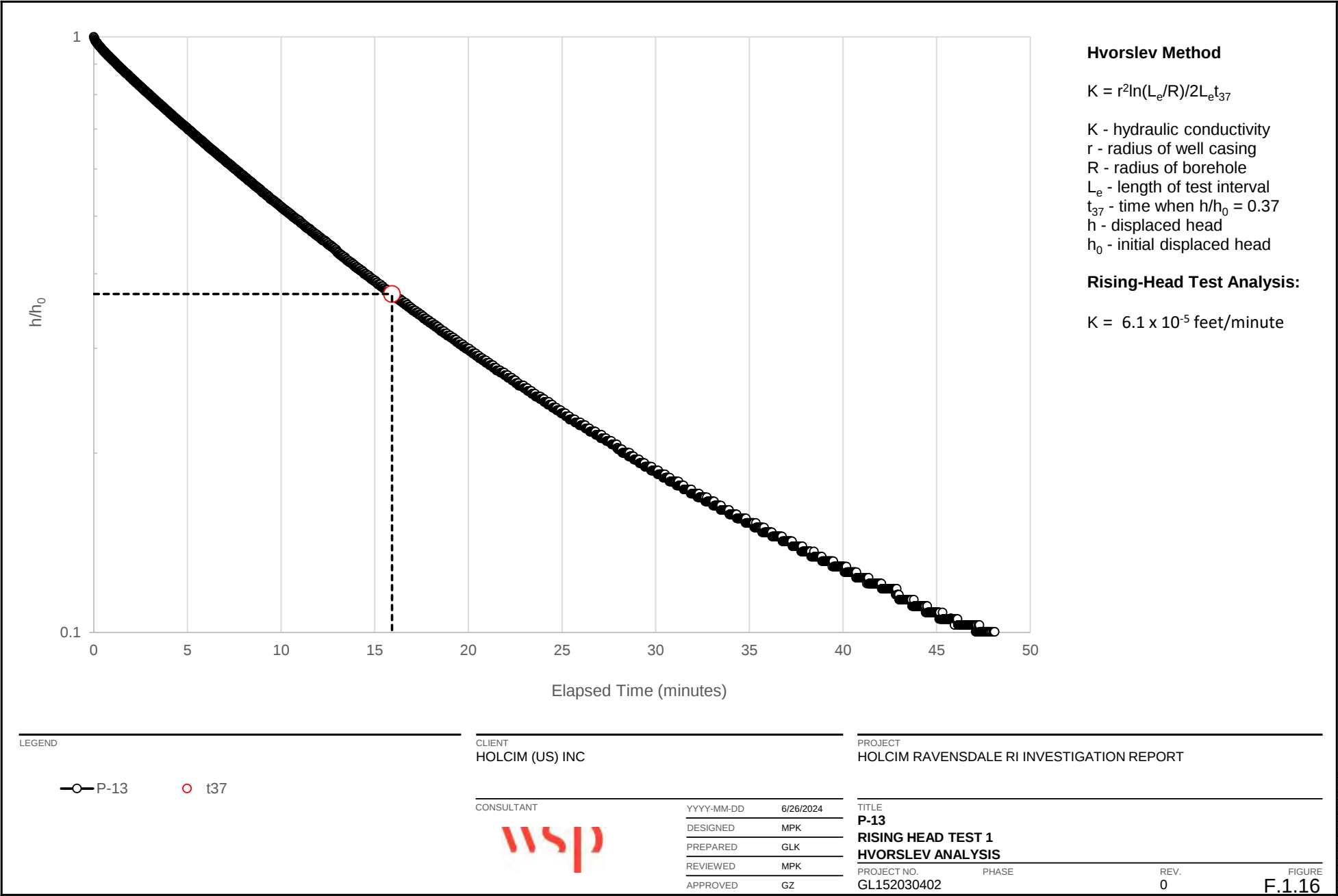
FIGURE
F.1.14

PATH: https://wsp.onlinenam.sharepoint.com/sites/GLD-119026/Project_Files/5_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/Slug Test Graphs USE THESE FOR REPORT/Data | FILE NAME: P-13_Hvorslev.xlsx



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

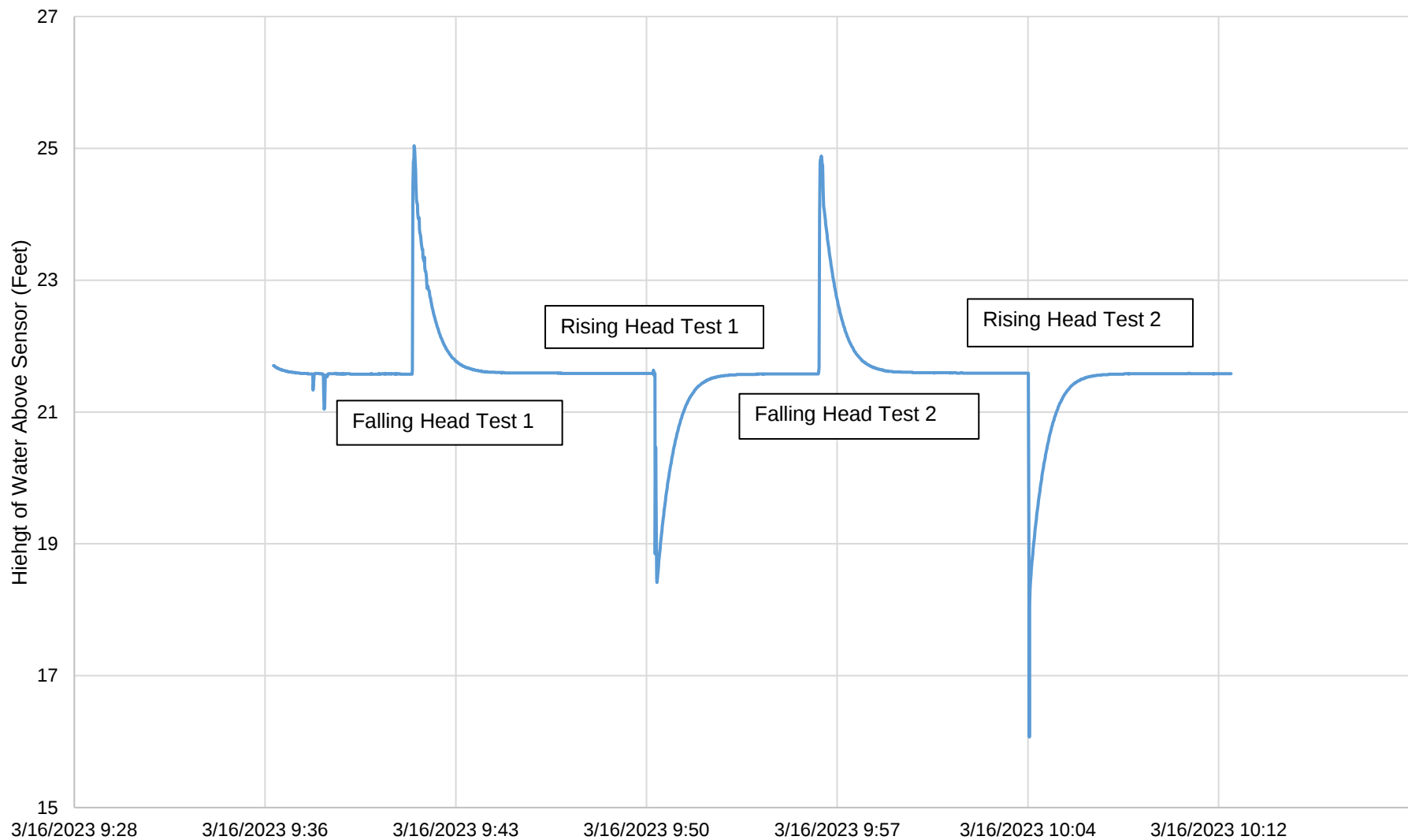
PATH: https://wsponlineinam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx_D/Slug_Test_Graphs_USE_THESE_FOR_REPORT/Data | FILE NAME: P-13_Hvorslev.xlsx



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

DRAFT

PATH: https://wsponline.nam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI_Report-Ecology/Appendix/Appx D/Slug Test Graphs USE THESE FOR REPORT/Data | FILE NAME: P-14 Hvorslev.xlsx



LEGEND

CLIENT
HOLCIM (US) INC

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

TITLE
P-14
SLUG TEST HYDROGRAPH

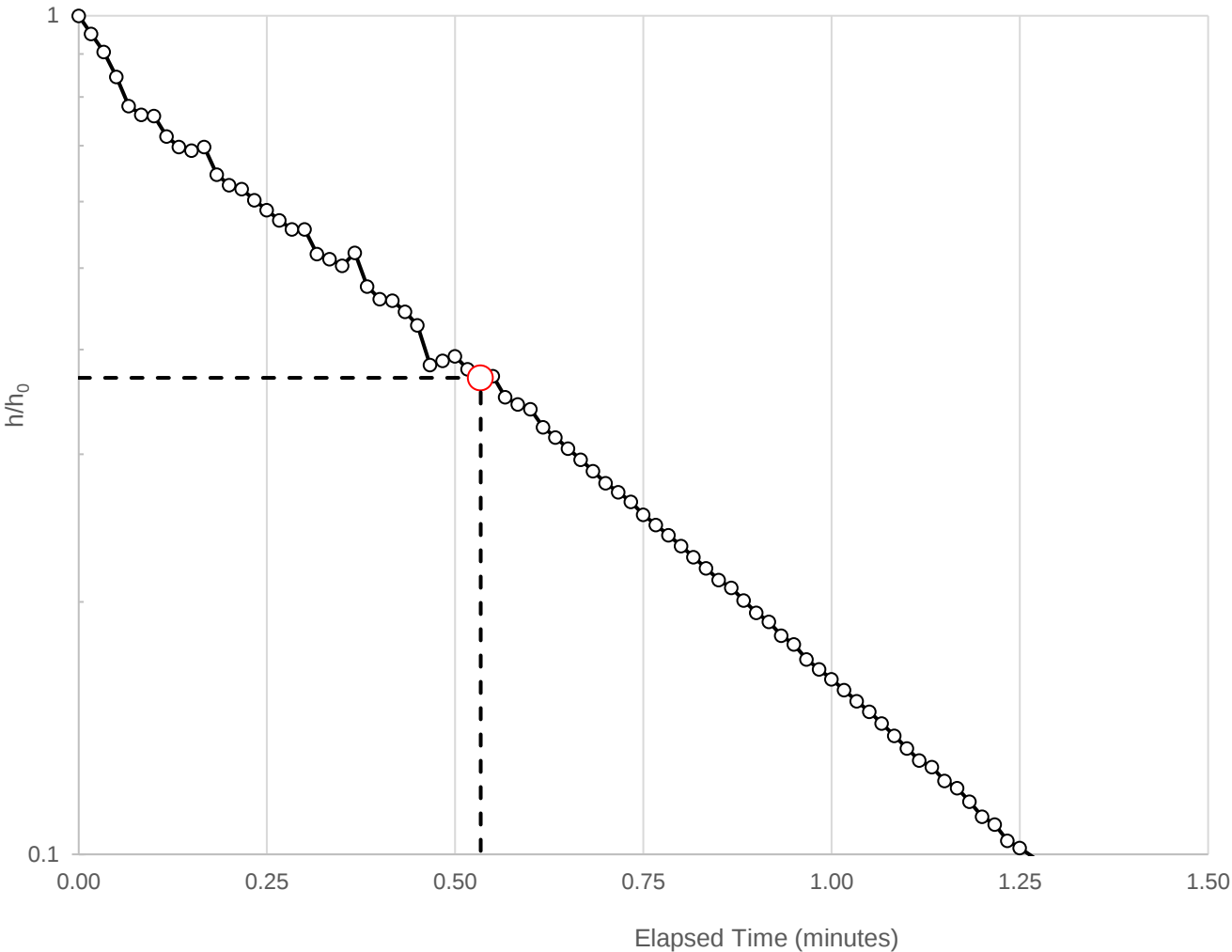
PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.17

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t₃₇ - time when h/h₀ = 0.37
- h - displaced head
- h₀ - initial displaced head

Falling-Head Test Analysis:

$K = 1.9 \times 10^{-3}$ feet/minute

LEGEND

○— P-14 ○ t₃₇

CLIENT
HOLCIM (US) INC

CONSULTANT



YYYY-MM-DD	2023-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

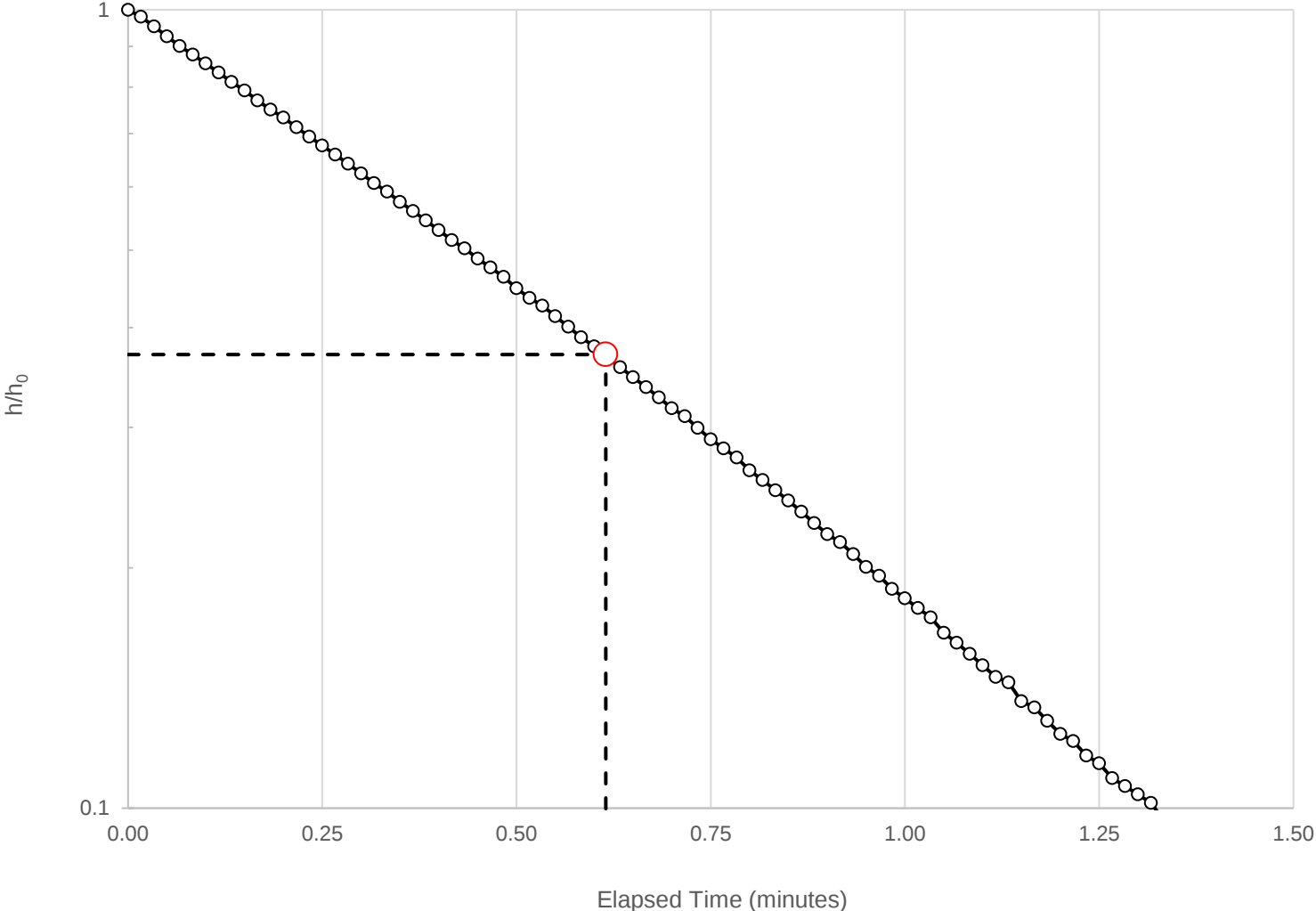
TITLE
P-14
FALLING HEAD TEST 1
HVORSLEV ANALYSIS

PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.18



Hvorslev Method

$$K = r^2 \ln(L_e/R) / 2L_e t_{37}$$

K - hydraulic conductivity
r - radius of well casing
R - radius of borehole
L_e - length of test interval
t₃₇ - time when h/h₀ = 0.37
h - displaced head
h₀ - initial displaced head

Rising-Head Test Analysis:

$$K = 1.6 \times 10^{-3} \text{ feet/minute}$$

LEGEND

—○— P-14 ○ t37

CLIENT
HOLCIM (US) INC

CONSULTANT

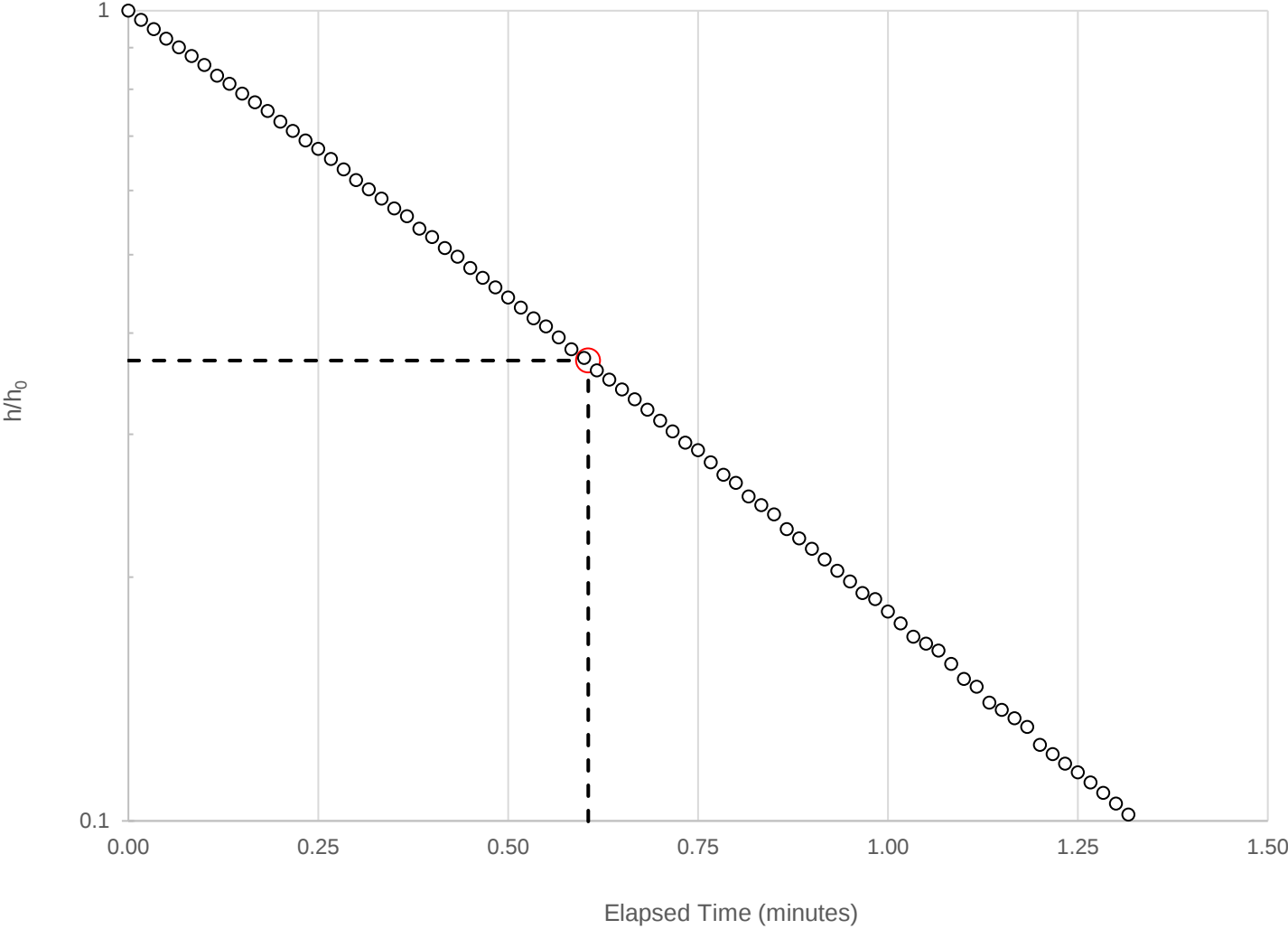


YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
P-14
RISING HEAD TEST 1
HVORSLEV ANALYSIS

PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.19



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t₃₇ - time when h/h₀ = 0.37
- h - displaced head
- h₀ - initial displaced head

Falling-Head Test Analysis:

$K = 1.6 \times 10^{-3}$ feet/minute

LEGEND

- P-14
- t₃₇

CLIENT
HOLCIM (US) INC

CONSULTANT

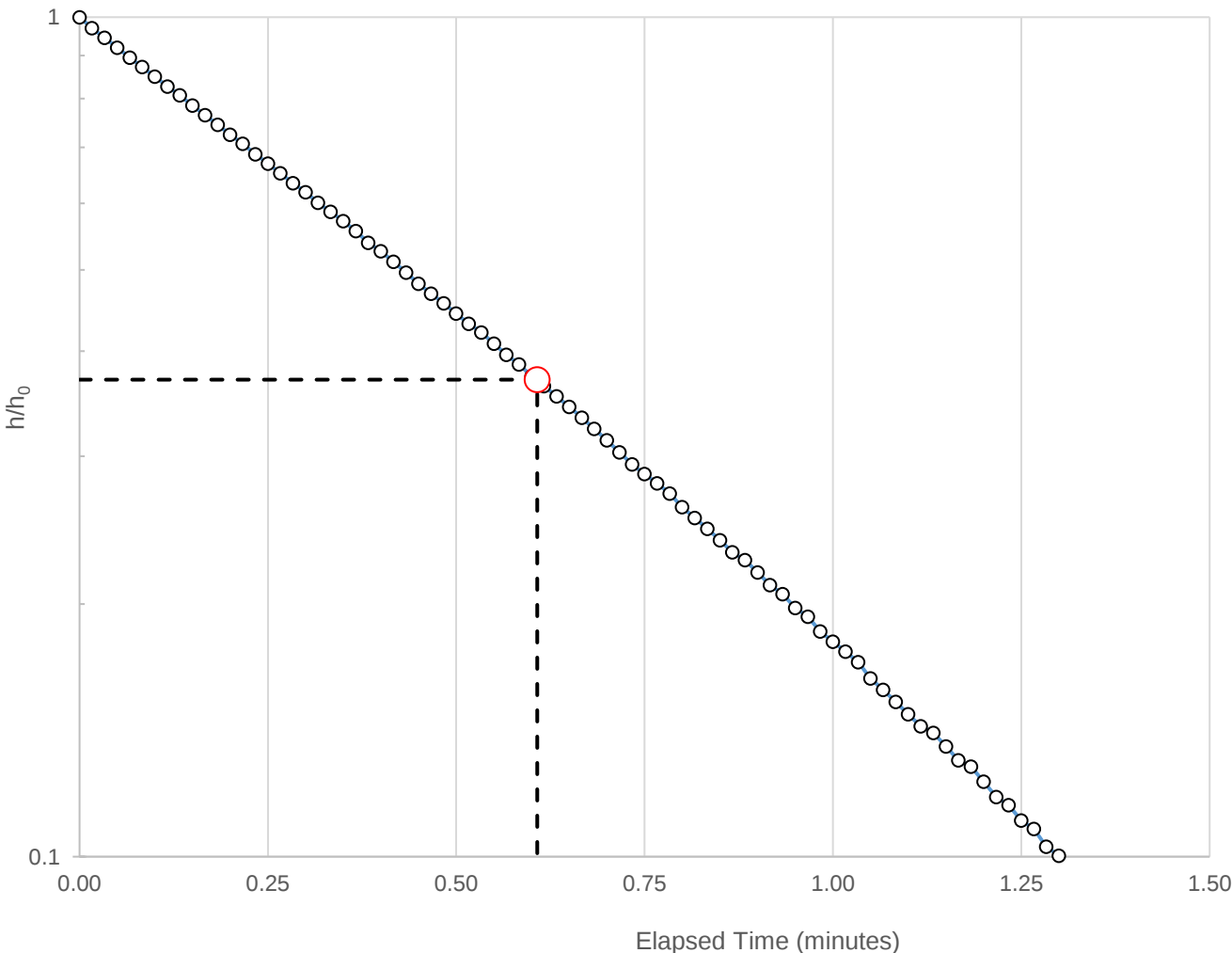


YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
P-14
FALLING HEAD TEST 2
HVORSLEV ANALYSIS

PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.20



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

K - hydraulic conductivity

r - radius of well casing

R - radius of borehole

L_e - length of test interval

t_{37} - time when $h/h_0 = 0.37$

h - displaced head

h_0 - initial displaced head

Rising-Head Test Analysis:

$K = 1.6 \times 10^{-3}$ feet/minute

LEGEND

○ P-14 ○ t37

CLIENT
HOLCIM (US) INC

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

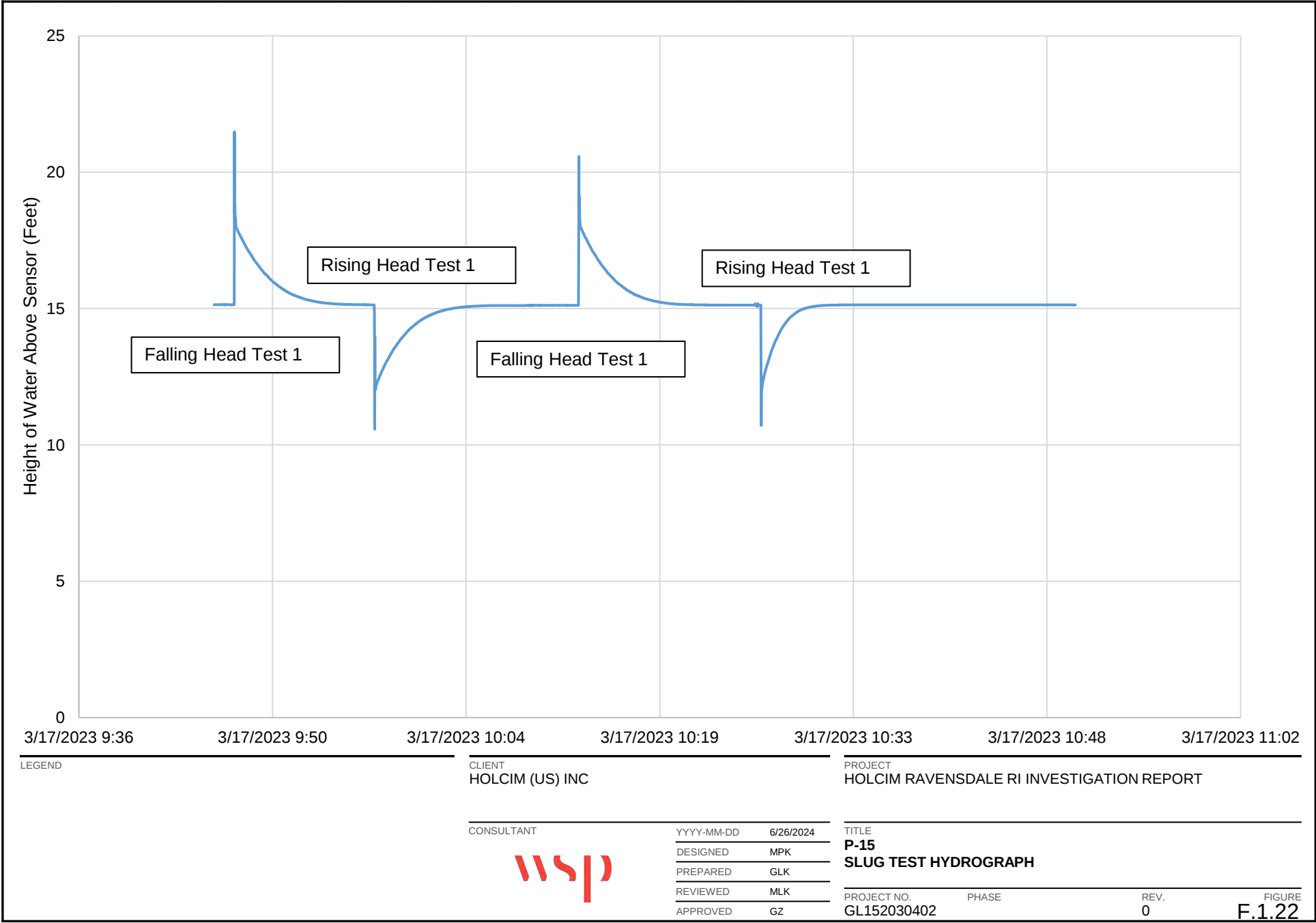
PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

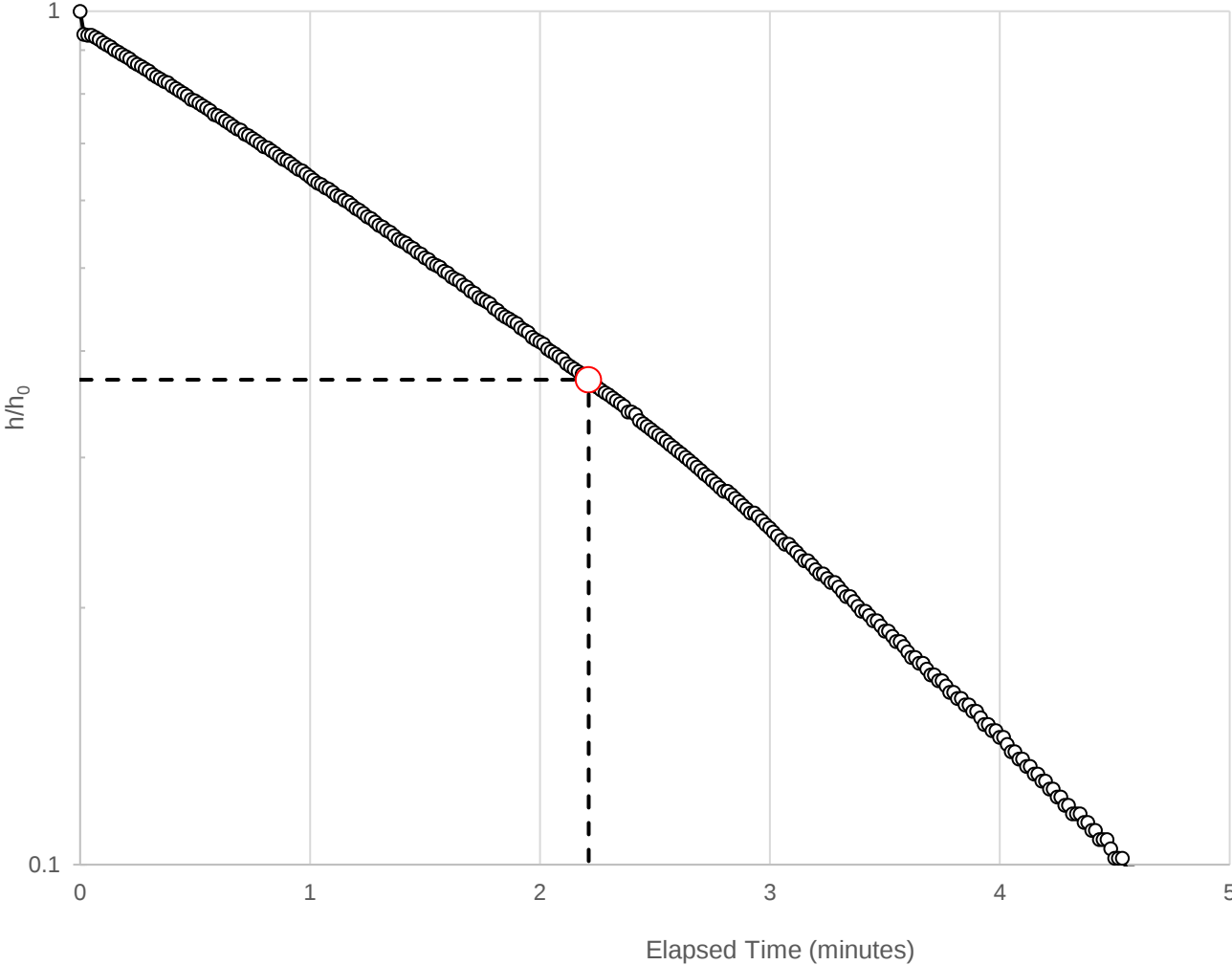
TITLE
P-14
RISING HEAD TEST 2
HVORSLEV ANALYSIS

PROJECT NO. GL152030402	PHASE	REV. 0	FIGURE F.1.21
----------------------------	-------	-----------	------------------

DRAFT

PATH: https://wsponline.nam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/Slug Test Graphs USE THESE FOR REPORT/Data | FILE NAME: P-15 Hvorslev.xlsx





Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t_{37} - time when $h/h_0 = 0.37$
- h - displaced head
- h_0 - initial displaced head

Falling-Head Test Analysis:

$K = 4.1 \times 10^{-4}$ feet/minute

LEGEND

○ P-15 ○ t37

CLIENT
HOLCIM (US) INC

CONSULTANT

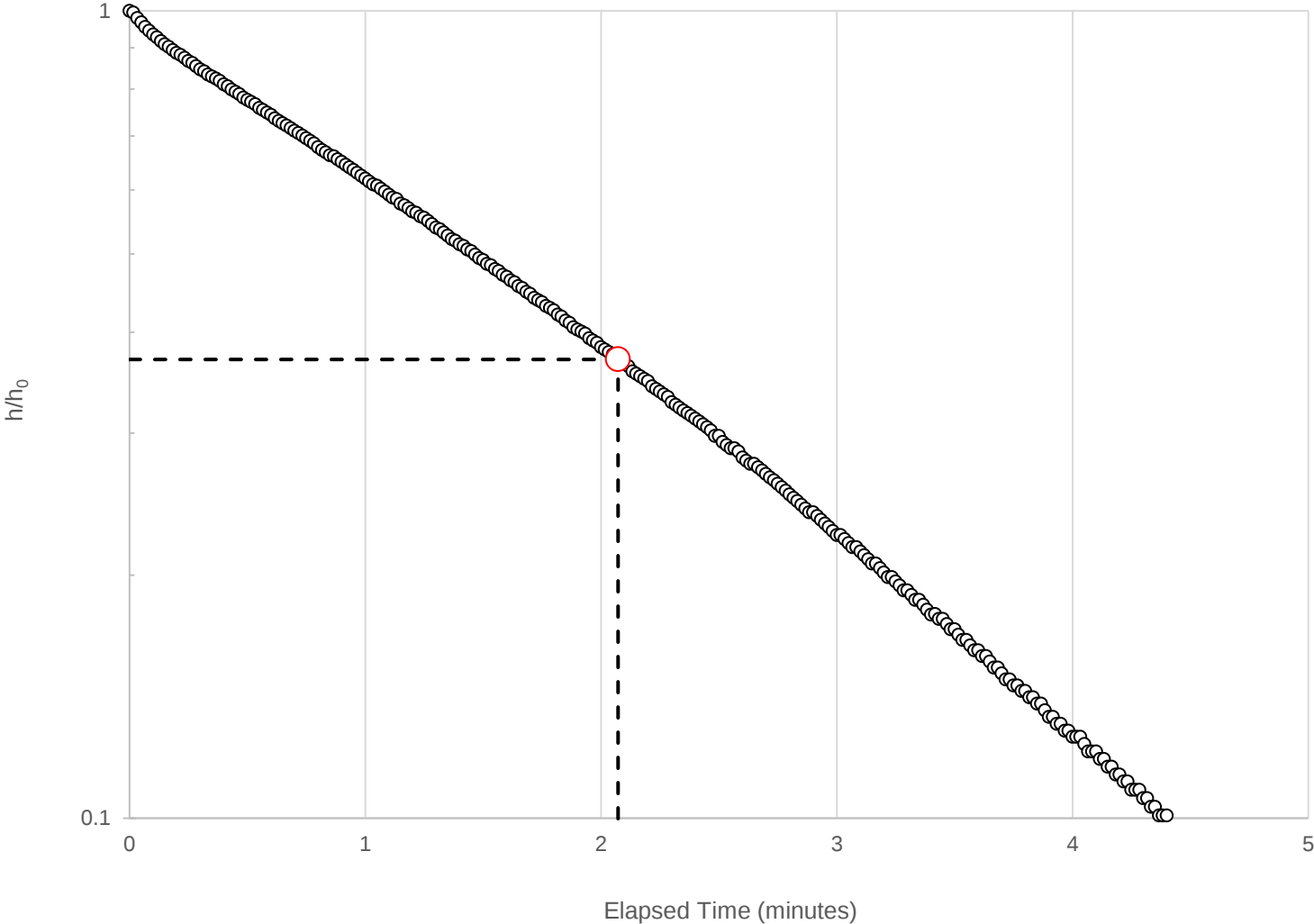


YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
P-15
FALLING HEAD TEST 1
HVORSLEV ANALYSIS

PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.23



Hvorslev Method

$$K = r^2 \ln(L_e/R) / 2L_e t_{37}$$

K - hydraulic conductivity
r - radius of well casing
R - radius of borehole
L_e - length of test interval
t₃₇ - time when h/h₀ = 0.37
h - displaced head
h₀ - initial displaced head

Rising-Head Test Analysis:

$$K = 4.4 \times 10^{-4} \text{ feet/minute}$$

LEGEND

—○— P-15 —○— t37

CLIENT
HOLCIM (US) INC

CONSULTANT

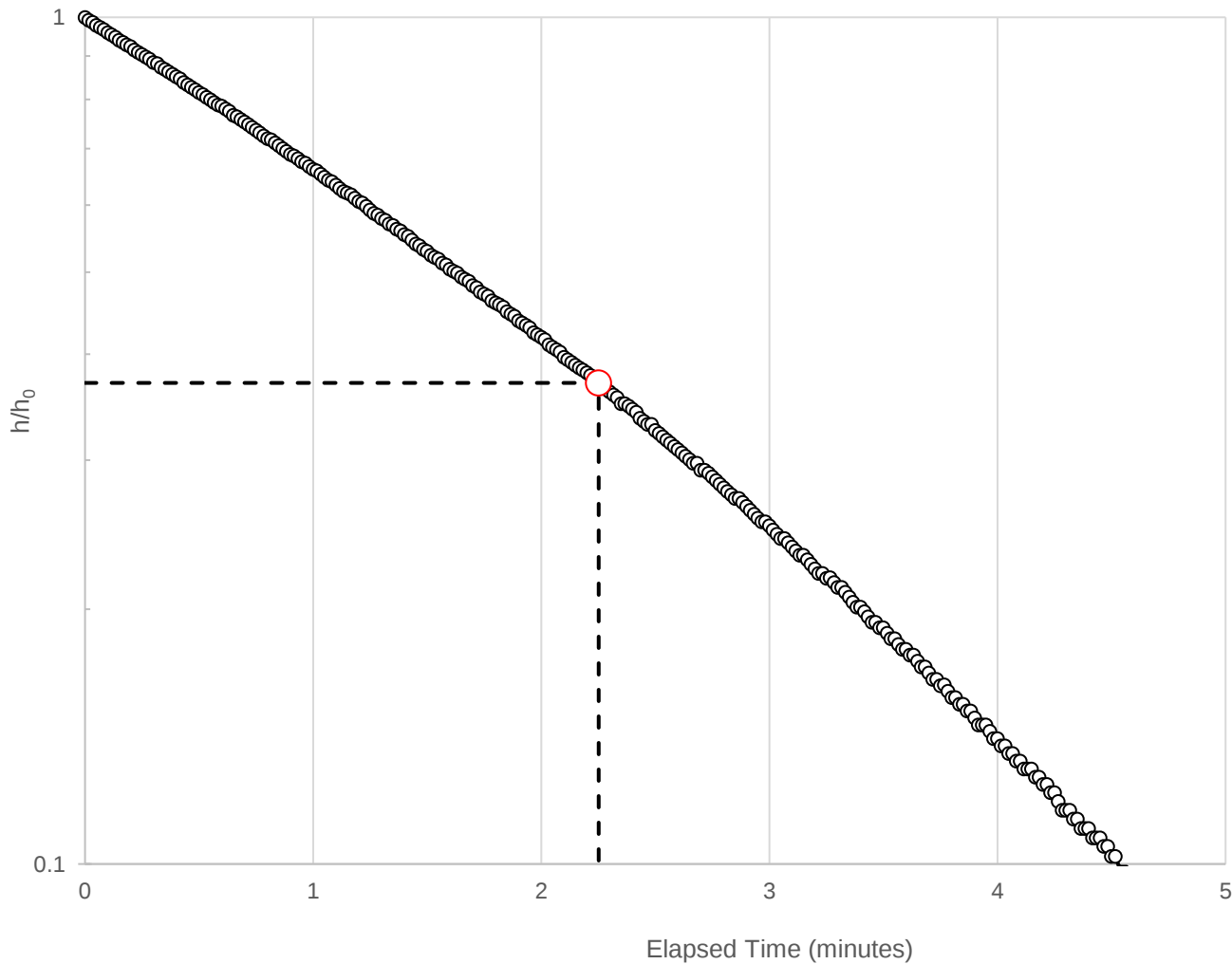


YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
P-15
RISING HEAD TEST 1
HVORSLEV ANALYSIS

PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.24



Hvorslev Method

$$K = r^2 \ln(L_e/R) / 2L_e t_{37}$$

K - hydraulic conductivity

r - radius of well casing

R - radius of borehole

L_e - length of test interval

t_{37} - time when $h/h_0 = 0.37$

h - displaced head

h_0 - initial displaced head

Falling-Head Test Analysis:

$$K = 4.0 \times 10^{-4} \text{ feet/minute}$$

LEGEND

○ P-15 ○ t37

CLIENT
HOLCIM (US) INC

CONSULTANT



YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

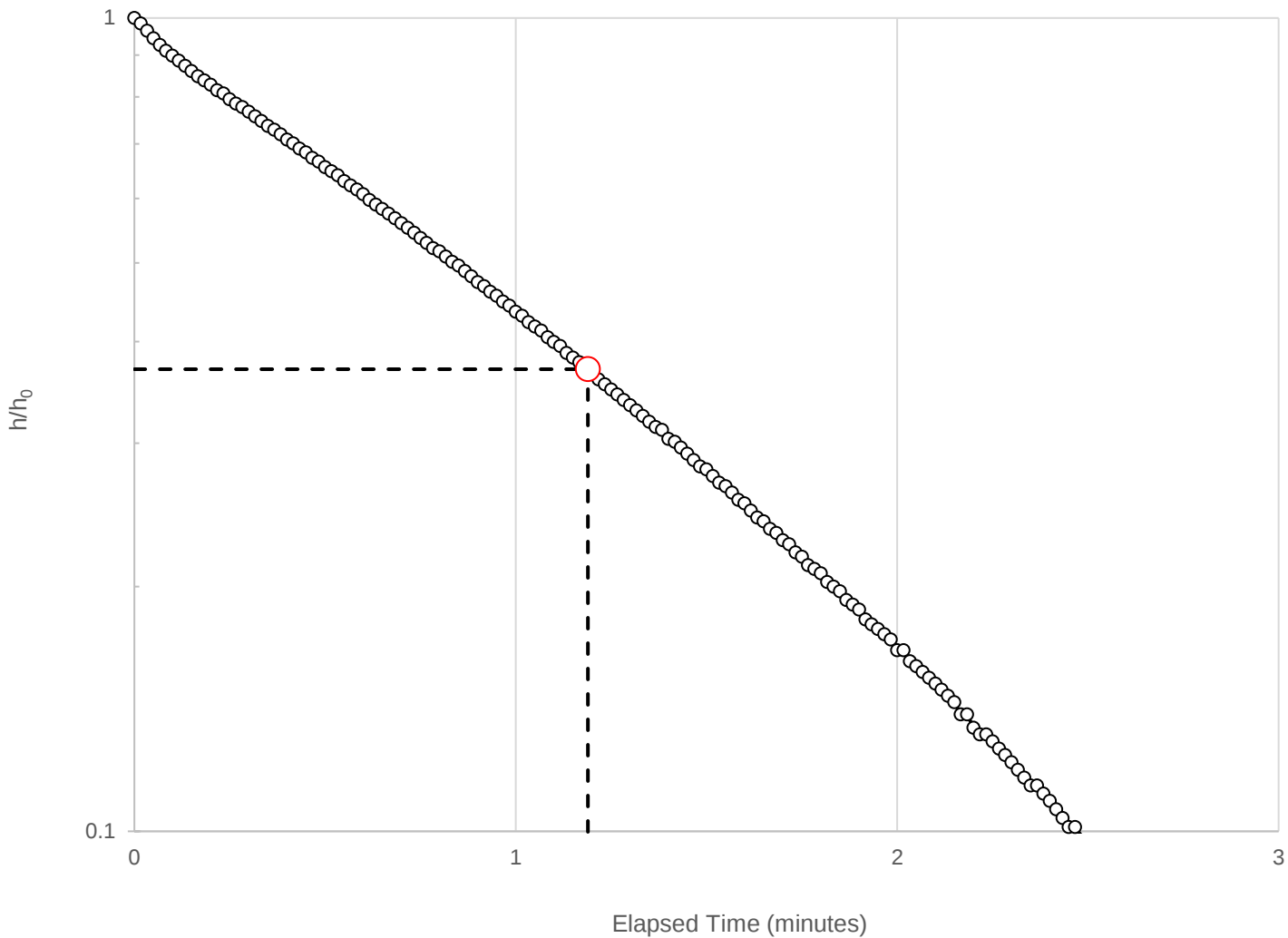
TITLE
P-15
FALLING HEAD TEST 2
HVORSLEV ANALYSIS

PROJECT NO.
GL152030402

PHASE

REV.
0

FIGURE
F.1.25



Hvorslev Method

$K = r^2 \ln(L_e/R) / 2L_e t_{37}$

- K - hydraulic conductivity
- r - radius of well casing
- R - radius of borehole
- L_e - length of test interval
- t₃₇ - time when h/h₀ = 0.37
- h - displaced head
- h₀ - initial displaced head

Rising-Head Test Analysis:

$K = 7.6 \cdot 10^{-4}$ feet/minute

LEGEND

- P-15
- t₃₇

CLIENT
HOLCIM (US) INC

CONSULTANT



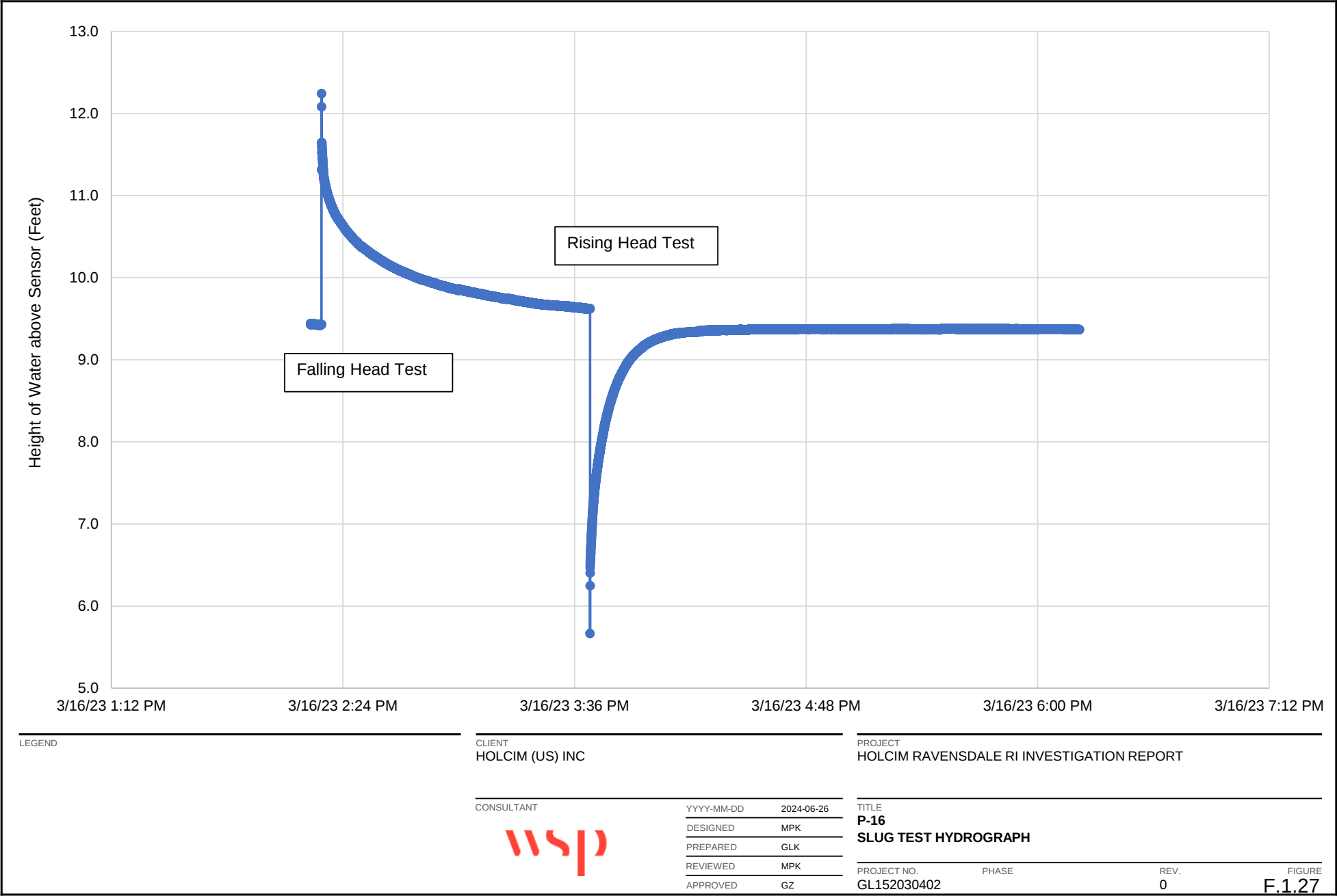
YYYY-MM-DD	2024-06-26
DESIGNED	MPK
PREPARED	GLK
REVIEWED	MLK
APPROVED	GZ

PROJECT
HOLCIM RAVENSDALE RI INVESTIGATION REPORT

TITLE
P-15
RISING HEAD TEST 2
HVORSLEV ANALYSIS

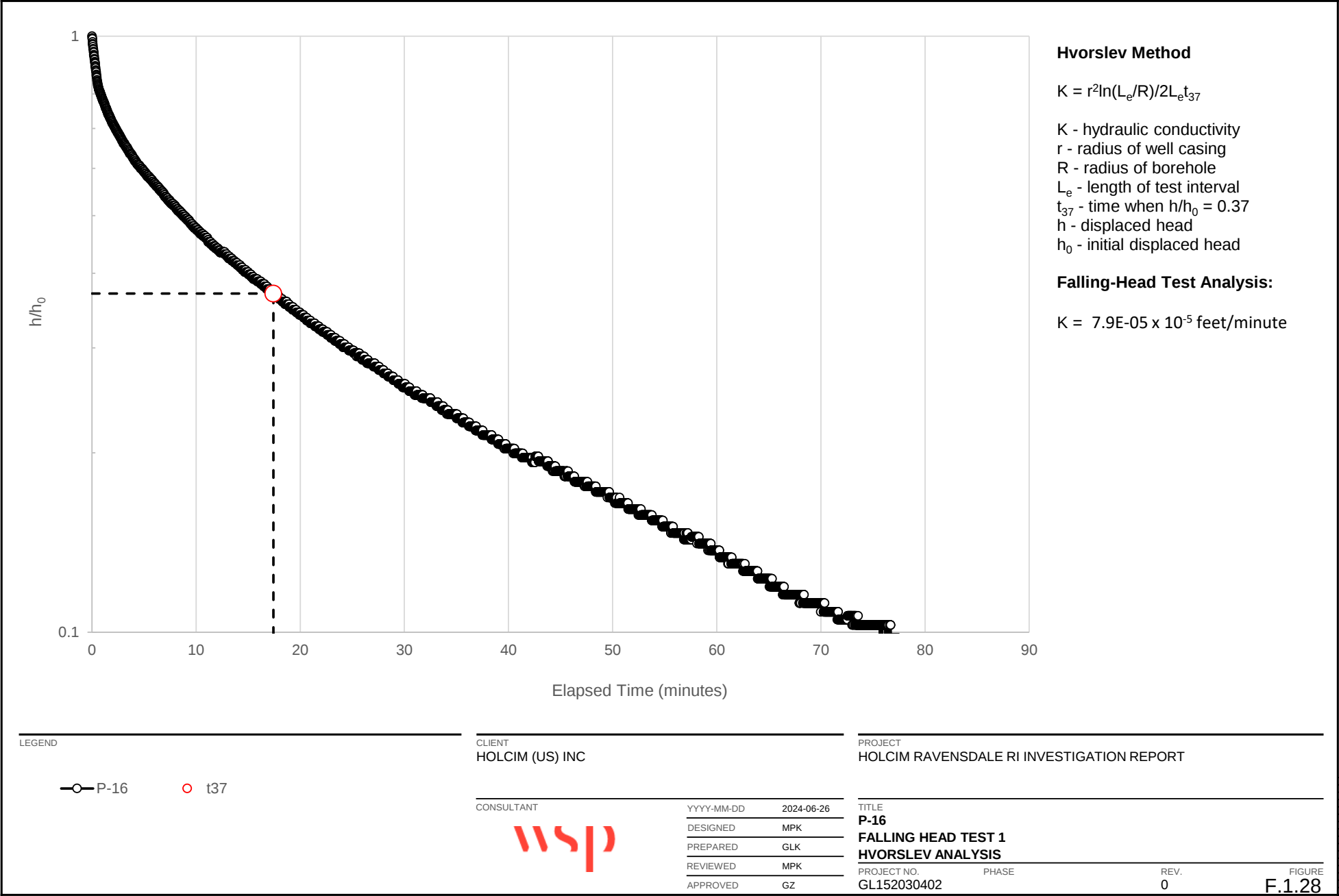
PROJECT NO.	PHASE	REV.	FIGURE
GL152030402		0	F.1.26

PATH: https://wsponline.nam.sharepoint.com/Sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx_D/Slug_Test_Graphs_USE_THESE_FOR_REPORT/Data | FILE NAME: P-16_Hydrlev.xlsx



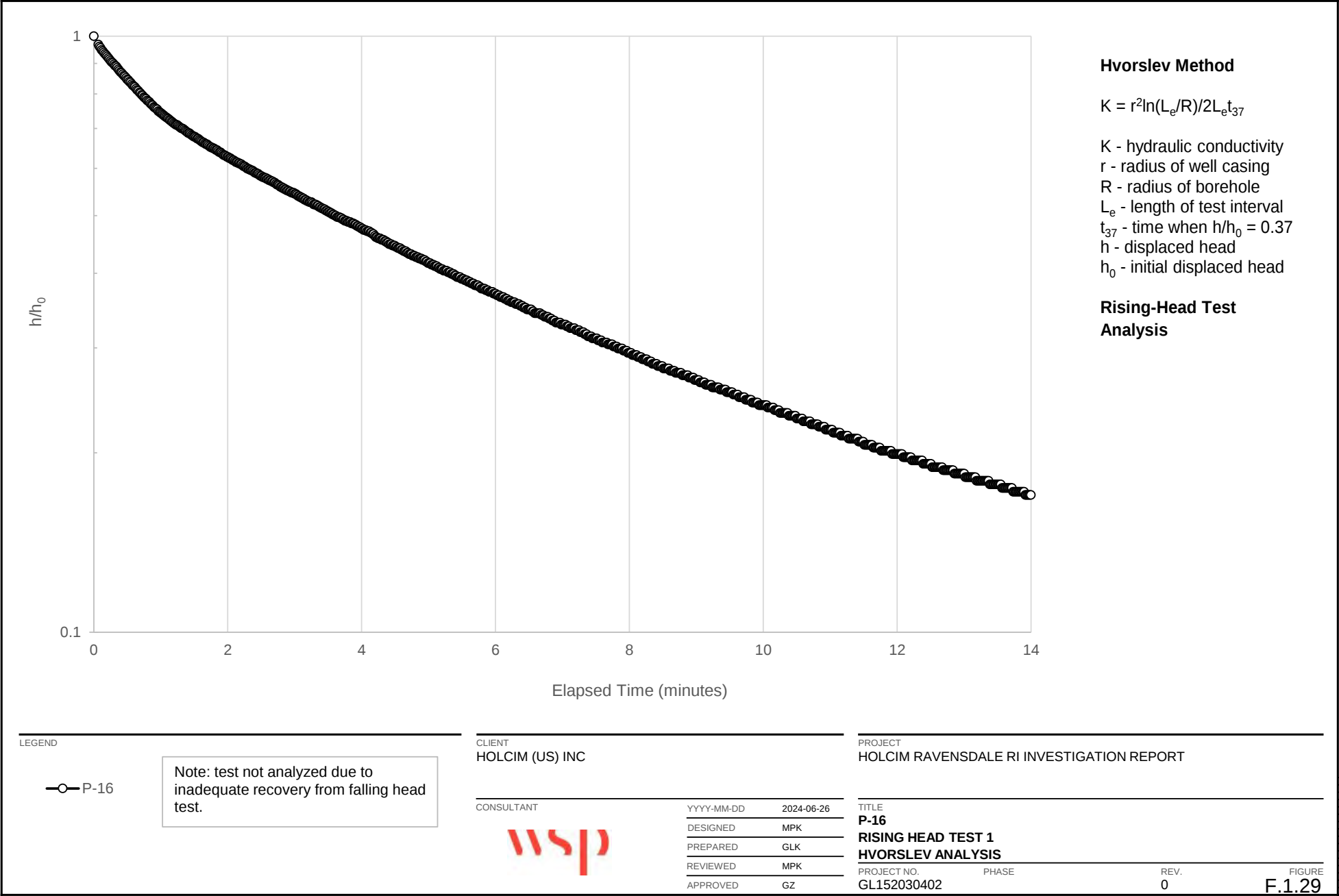
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

PATH: https://wsponlineinam.sharepoint.com/sites/GLD-119026/Project_Files/6_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/Slug Test Graphs USE THESE FOR REPORT/Data | FILE NAME: P-16_Hvorslev.xlsx



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

PATH: https://wsp.onlinenam.sharepoint.com/sites/GLD-119026/Project_Files/5_Deliverables/2023-RI_Report/2024-06-RI-Report-Ecology/Appendix/Appx D/Slug Test Graphs USE THESE FOR REPORT/Data | FILE NAME: P-16_Hvorslev.xlsx



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

Appendix F.2: Summary of Dimensions for each Cross-section, P-16 and Infiltration Trench

Table F.2.1 Summary of Dimensions for each Cross-section, P-16 and Infiltration Trench

Location	Length (feet)	Aquifer Thickness (feet)	Cross-sectional Area of Aquifer (feet²)	Min Rate (gpm)	Max Rate (gpm)
D-D'	300	6	1778	1	1
C-C'	350	25	8750	7	9
P-16	140	2.51	351.4	0.07	0.07
Infiltration Trench (Manual Measurements)	NA	NA	NA	5.5	13

Notes:

gpm - gallons per minute

NA - Not Applicable

Appendix F.3: Specific Capacities

Table F.3.1: Specific Capacities

$$s = \frac{2.303Q}{4\pi T} \log\left(\frac{2.25Tt}{r^2 S}\right) \quad (6)$$

<http://www.aqtesolv.com/cooper-jacob.htm>

JACOBS			
MTCA Minimum Rate (Q = 0.5 gpm)			
P-16		B-15	
Q (gpm)	0.5	Q (gpm)	0.5
Q (ft3/d)	96.3	Q (ft3/d)	96.3
t (d)	0.01	t (d)	0.01
S [-]	0.15	S [-]	0.15
r (ft)	0.08	r (ft)	0.08
K (ft/d)	0.11	K (ft/d)	0.14
b (ft)	7.0	b (ft)	10.0
T (ft2/d)	0.8	T(ft2/d)	1.4

(15 minutes)

s (ft)	27
--------	----

s (ft)	18
--------	----

FORMULA CHECK:	
1st term	22.224387
2nd term	1.2341106
s (ft)	27.427351

FORMULA CHECK:	
1st term	12.4457
2nd term	1.48592
s (ft)	18.4933

Maximum Sustainable Rate			
P-16		B-15	
Q (gpm)	0.08	Q (gpm)	0.19
Q (ft3/d)	16.4	Q (ft3/d)	36.7
t (d)	0.04	t (d)	0.04
S [-]	0.2	S [-]	0.2
r (ft)	0.1	r (ft)	0.1
K (ft/d)	0.1	K (ft/d)	0.1
b (ft)	7.0	b (ft)	10.0
T (ft2/d)	0.8	T(ft2/d)	1.4

(one hour)

s (ft)	7
--------	---

s (ft)	10
--------	----

DRISCOLL			
P-16		B-15	
K (ft/d)	0.11	K (ft/d)	0.14
b (ft)	7	b (ft)	10
T(ft2/d)	0.8	T(ft2/d)	1.4
T (gpd/ft)	5.9	T (gpd/ft)	11
s (ft)	7	s (ft)	10

ft2/d --> gpd/ft:
T=1500*Q/s
Q = Ts/1500

7.4805

Q (gpm)	0.03
---------	------

Q (gpm)	0.07
---------	------

