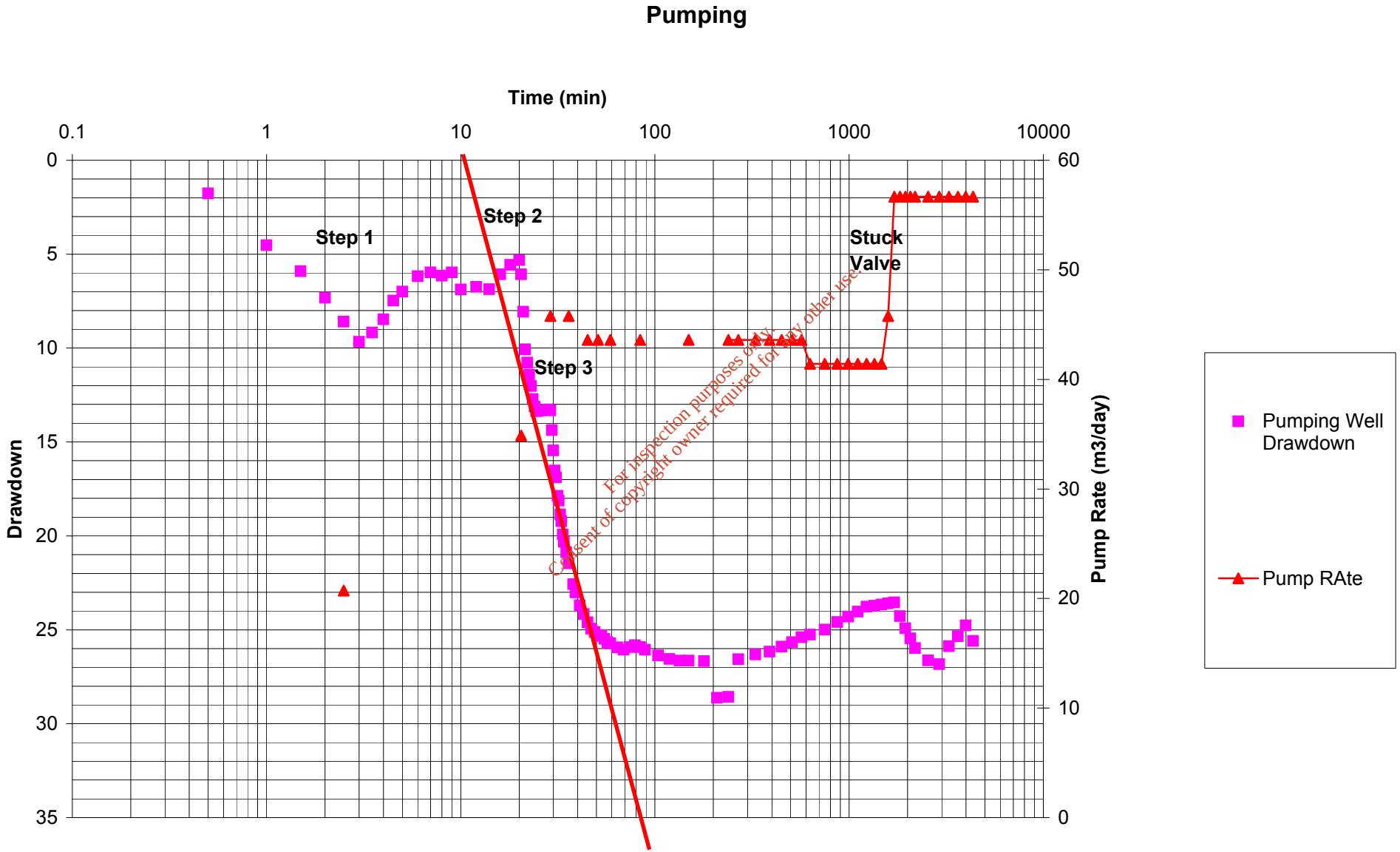
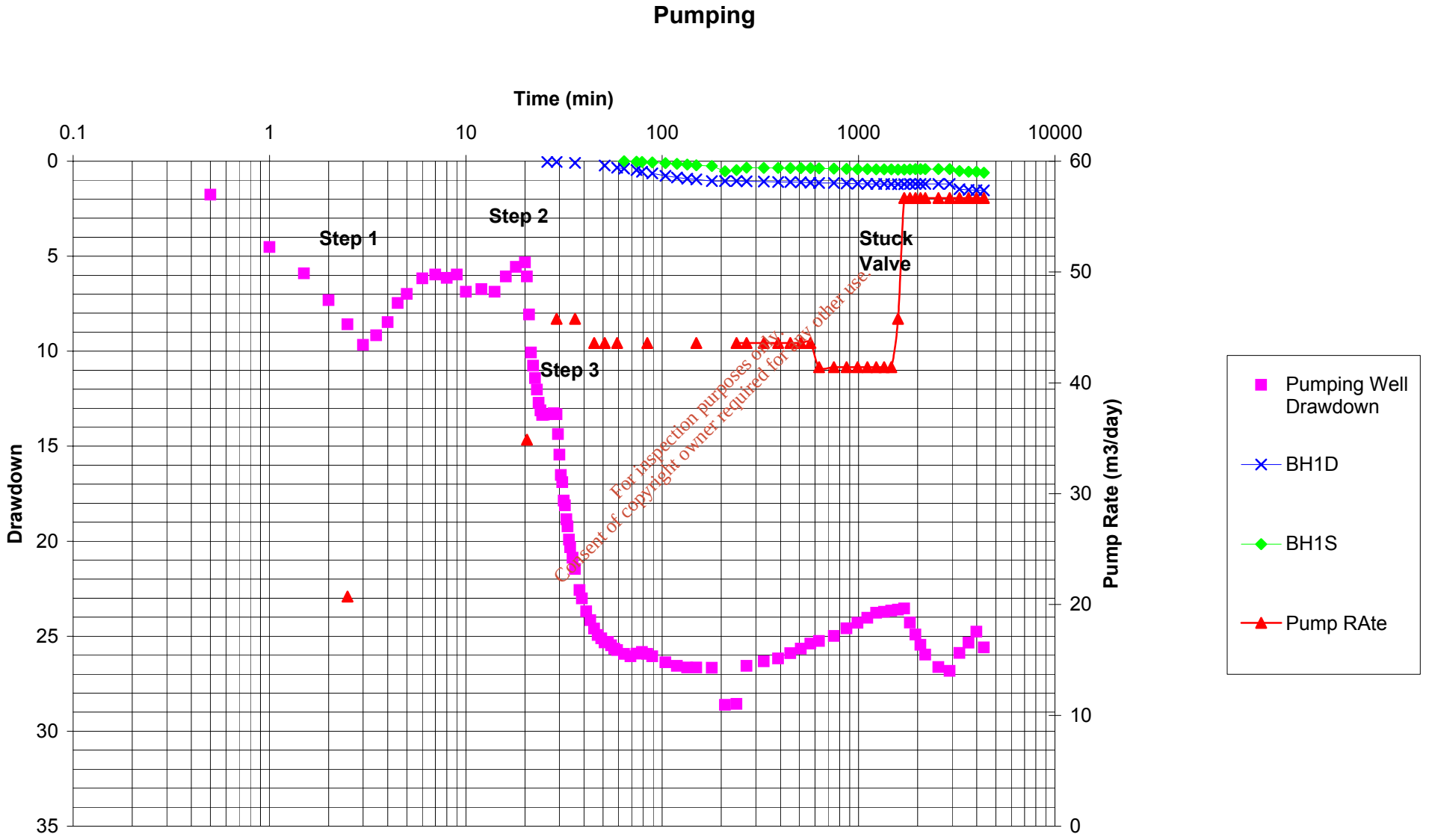
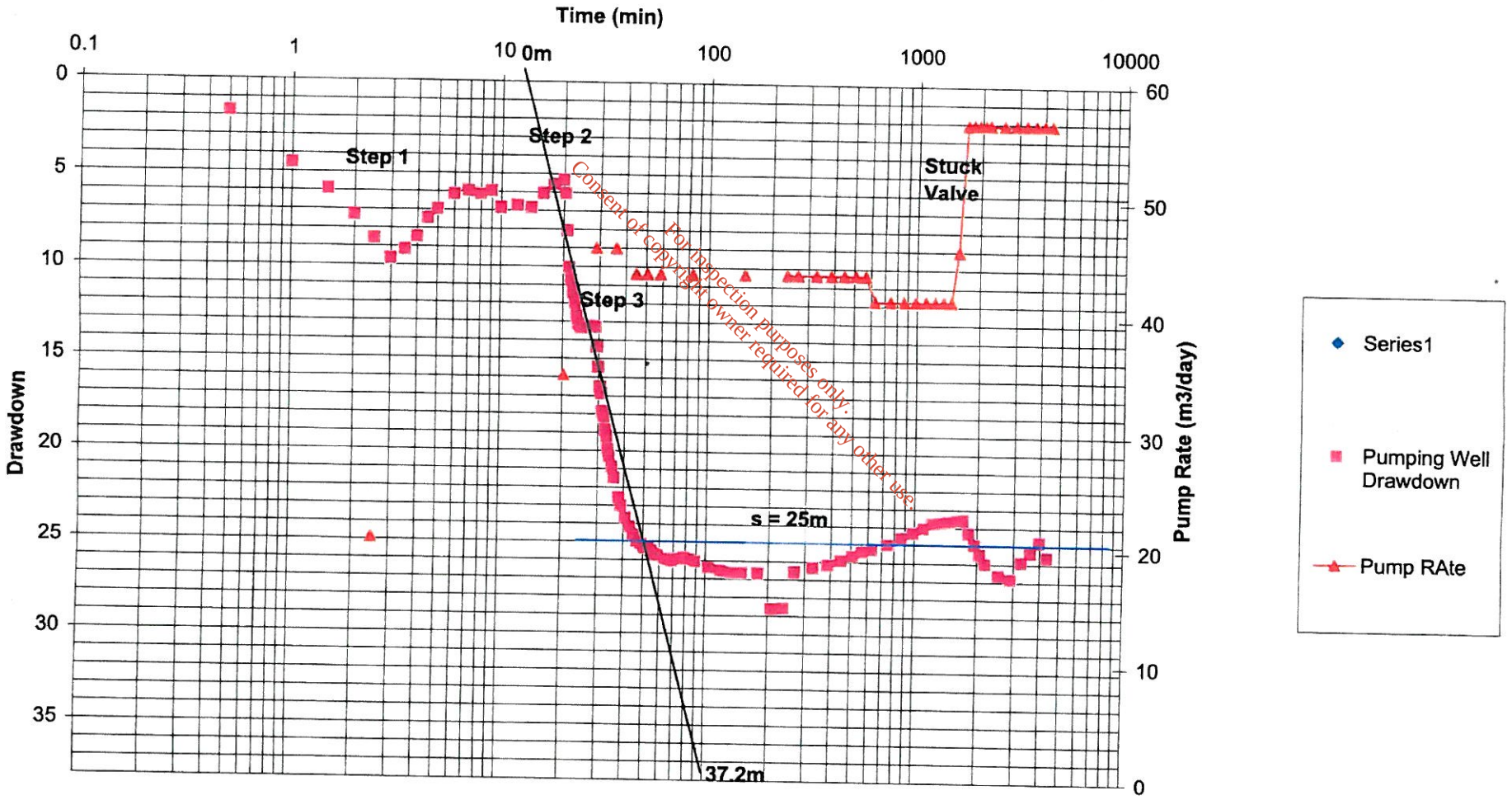
# APPENDIX 2.4.7
# Pump Test Data





# APPENDIX 2.4.8
# Pump Test Calculation Sheets and Graphs



Project Sheet

TES

Project: BNM - DREHID LANDFILL

Project No: 1131

Title: TES - GWE PUMP TEST DRAWDOWN T-CALCS

Prepared: KM

Reference

Comment/Action

JACOB STRAIGHT LINE FORMULA

$$T = \frac{2.3Q}{4\pi\Delta s}$$

Q = PUMPING RATE ($m^3/d$)

$\Delta s$ = DRAWDOWN PER LOG CYCLE (m)

10-100 MINUTES

$Q = 43.6\ m^3/d$

$\Delta s_{10-100} = 37.2\ m$

$$T = \frac{2.3 \times 43.6 m^3/d}{4\pi \times 37.2 m} = 0.215\ m^2/d$$

---

LOGAN APPROXIMATION CALCULATION

$$T = \frac{1.22Q}{s}$$

Q = PUMPING RATE ($m^3/d$)

s = DRAWDOWN IN WELL (m)

s varies between 23m and 27m but averages at 25m $s = 25m$

$Q = 48.5\ m^3/d$

$$T = \frac{1.22 \times 48.5 m^3/d}{25m} = 2.37 m^2/d$$

---

RESULTS:

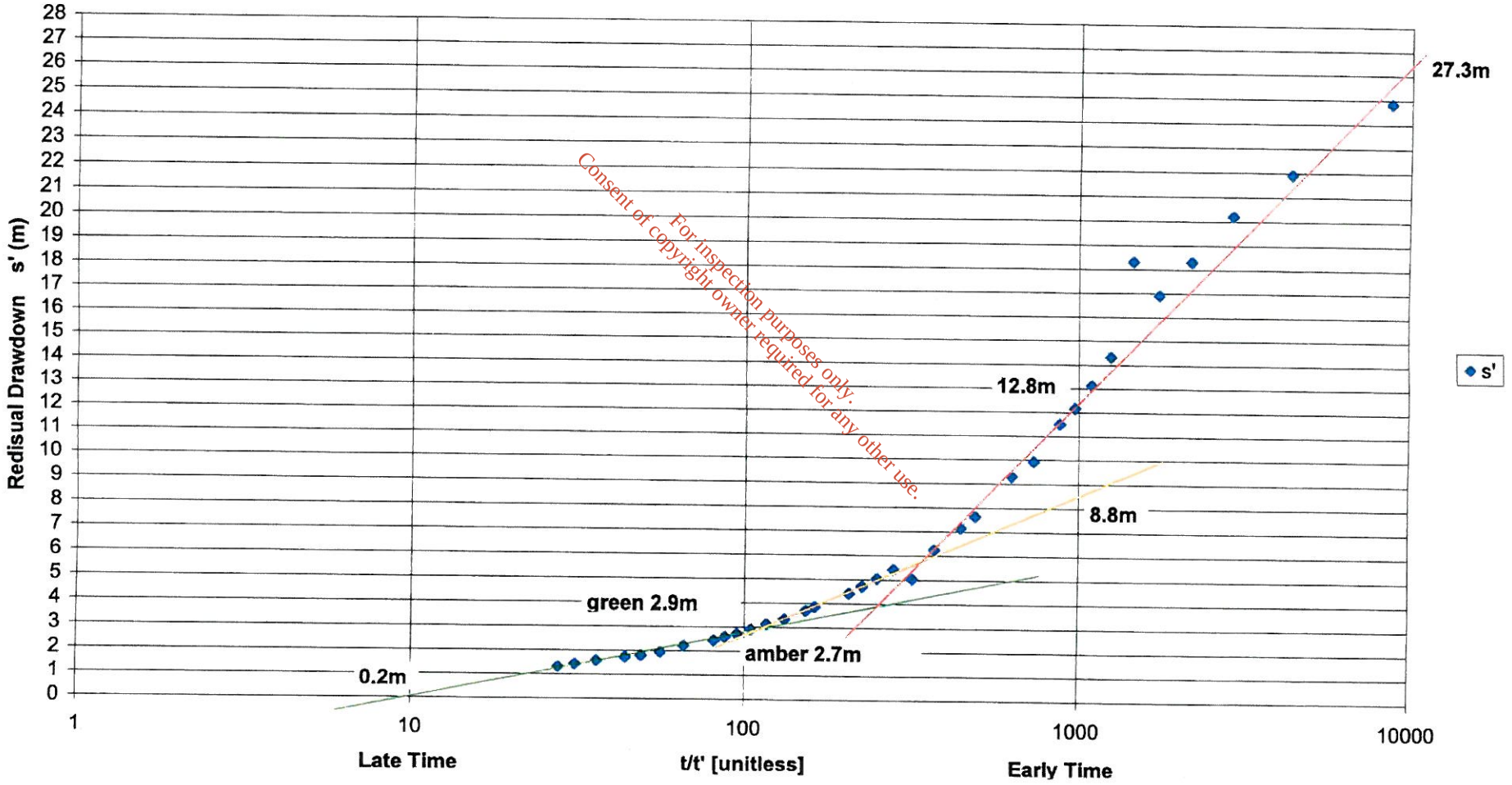
JACOB TRANSMISSIVITY 10 - 100 minutes

$T = 0.215\ m^2/d$

LOGAN APPROXIMATION TRANSMISSIVITY 100 - 4349 minutes

$T = 2.37 m^2/d$

## Recovery Data plot for GW6PW Drehid
## Showing Jacob Slopes used for Calculations



Project Sheet

TES CONSULTING ENGINEERS

Project: BNM - DREHID LANDFILL
Subject: TES - GW6 PUMP TEST RECOVERY T-CALCS
Project No: 1131
Design / Minutes / Telephone Log / Other Record: ✓
Sheet No: 1 of 2
Date:
Prepared: KM
Checked:

## JACOB STRAIGHT LINE RECOVERY FORMULA

$$T = \frac{2.3Q}{4\pi \times \Delta s'}$$

$\Delta s'$ = CHANGE IN RESIDUAL DRAWDOWN PER LOG CYCLE (m)

$Q = \bar{Q}$, AVERAGE PUMP RATE FOR TEST ($m^3/d$)

$= 148.40 m^3$ PUMPED OVER 4349 MINUTES (72 hours = 4,320 minutes)

$= 49.14 m^3/d$

**LATE TIME**

$\Delta s' = 2.9m - 0.2m = 2.7m$

$T = \frac{2.3 \times 49.14 m^3/d}{4\pi \times 2.7m} = 3.33 m^2/d$

---

**MID TIME**

$\Delta s' = 8.8m - 2.7m = 6.1m$

$T = \frac{2.3 \times 49.14 m^3/d}{4\pi \times 6.1m} = 1.47 m^2/d$

**EARLY TIME**

$\Delta s' = 27.3m - 12.8m = 14.5m$

$T = \frac{2.3 \times 49.14 m^3/d}{4\pi \times 14.5m} = 0.62 m^2/d$

---

RESULTS USING $\bar{Q} = 49.14 m^3/d$

| | | |
|---|---|---|
| LATE TIME | $T =$ | $3.33 m^2/d$ |
| MID TIME | $T =$ | $1.47 m^2/d$ |
| EARLY TIME | $T =$ | $0.62 m^2/d$ |
| MEAN | $T =$ | $1.81 m^2/d$ |

Project Sheet

TES CONSULTING ENGINEERS

Project: BNM – DRISHID LANDFILL

Subject: TES-GWS PUMP TEST RECOVERY T-CALCS

Job No: 1131

Check: ✓

Sheet No: 2 of 2

Revision No:

Date:

Prepared: AM

Checked:

IF $Q_{max} = 56.68 m^3/d$

LATE TIME

$\Delta s' = 2.7m$

$T = \frac{2.3 \times 56.68 m^3/d}{4\pi \times 2.7m} = 3.84 m^2/d$

MID TIME

$\Delta s' = 6.1m$

$T = \frac{2.3 \times 56.68 m^3/d}{4\pi \times 6.1m} = 1.70 m^2/d$

EARLY TIME

$\Delta s' = 14.5m$

$T = \frac{2.3 \times 56.68 m^3/d}{4\pi \times 14.5m} = 0.72 m^2/d$

RESULTS USING $Q_{max} = 56.68 m^3/d$

LATE TIME $T = 3.84 m^2/d$

MID TIME $T = 1.70 m^2/d$

EARLY TIME $T = 0.72 m^2/d$

MEAN $T = 2.09 m^2/d$

$$T = \frac{q \times \ln\left(\frac{1}{r} \times \sqrt{\left(\frac{Q}{\pi E}\right)}\right)}{2\pi}$$

$q$ = SPECIFIC CAPACITY $(m^3/d/m)$ $= \frac{48.5 m^3/d}{25m} = 1.94 m^3/d/m$

$r$ = radius of BOREHOLE TUBE $(m)$ $= 0.150m$

$Q$ = PUMPING RATE $(m^3/d)$ $= 48.5 m^3/d$

$E$ = RECHARGE RATE $(m/d/m^2)$ $= 5 \times 10^{-4} m/d/m^2$*

*stated AS ESTIMATED RECHARGE RATE FOR MIDLAND AQUIFER IN PAPER - TAKEN FROM SEVERAL STUDIES.

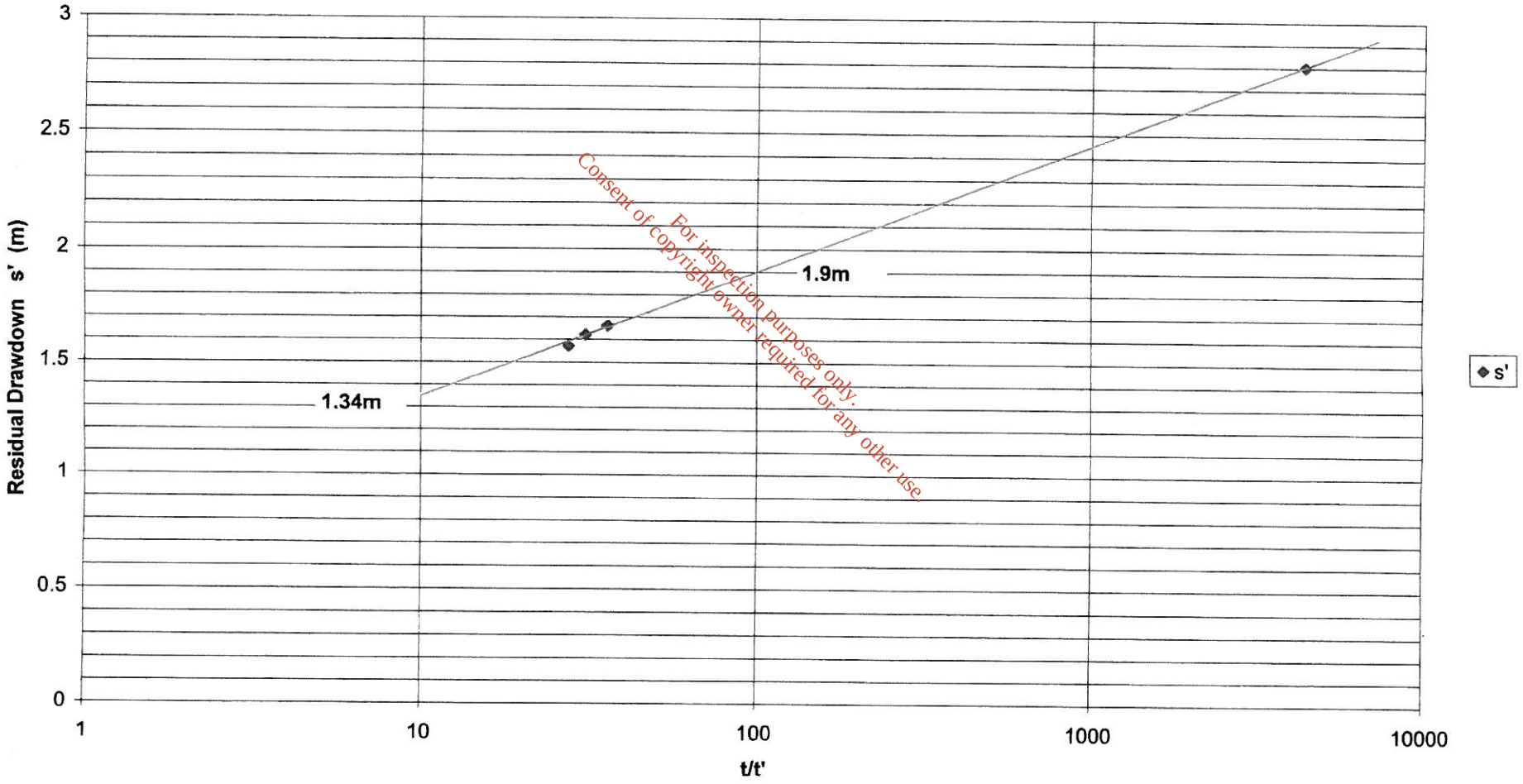
$$T = \frac{1.94 m^3/d/m \times \ln\left(\frac{1}{0.15} \times \sqrt{\frac{48.5 m^3/d}{\pi \times 5 \times 10^{-4} m/d/m^2}}\right)}{2\pi}$$

$$= \frac{1.94 m^3/d/m \times \ln\left(1.7572 \times 10^3\right)}{2\pi}$$

$$= \frac{1.94 m^3/d/m \times 7.472}{2\pi}$$

$$T = 2.31 m^2/d$$

**Recovery Test data at BH1D**
**Showing Jacob Slope used for Calculations**



Project Sheet

TES CONSULTING ENGINEERS

Project: BNM - DREHID LANDFILL
Element: TES - GW6 PUMP TEST
Title: GW10 RECOVERY T-CALC
Project No: 1131
Design / Models / Telephone Log / Other Record
Sheet No / Revision No / Date / Prepared / Checked / Original Action

JACOBS STRAIGHT LINE RECOVERY FORMULA

$$T = \frac{2.3Q}{4\pi \Delta s'}$$

$\Delta s'$ = CHANGE IN RESIDUAL DRAWDOWN PER LOG-CYCLE (m)

$Q = \bar{Q}$, AVERAGE PUMPING RATE FOR TEST ($m^3/d$)

148.4 m3 OVER 4349 MINUTES (72 HOURS = 4,320 minutes)

$= 49.14\ m^3/d$

$Q_{max}$ = MAXIMUM PUMPING RATE DURING TEST ($m^3/d$)

$Q_{max} = 56.68\ m^3/d$

$\Delta s (1.9m - 1.34m) = 0.56m$

$\bar{Q}$ $\quad T = \frac{2.3 \times 49.14\ m^3/d}{4\pi \times 0.56m} = 16.06\ m^2/d$

$Q_{max}$ $\quad T = \frac{2.3 \times 56.68\ m^3/d}{4\pi \times 0.56} = 18.53\ m^2/d$



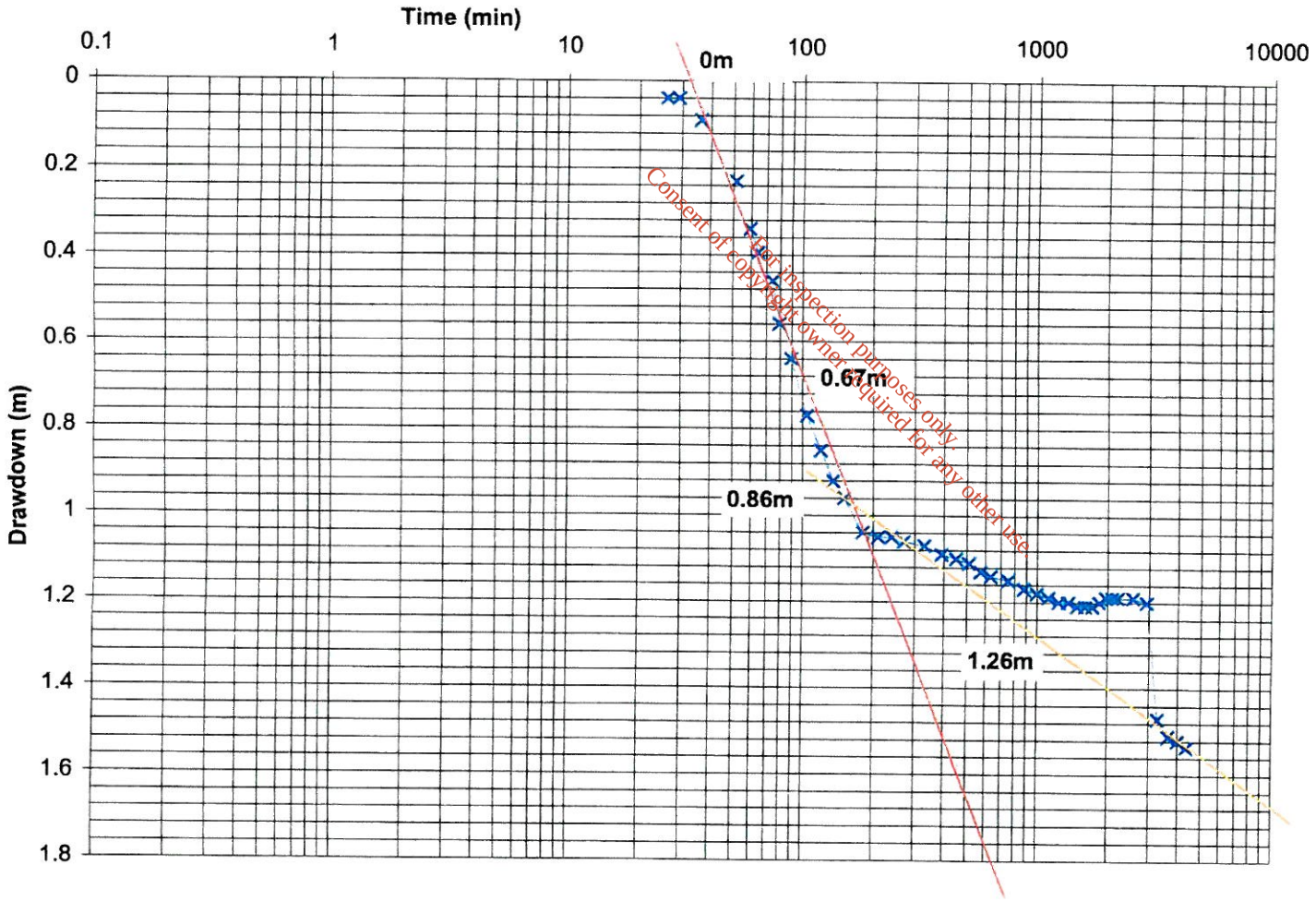
RESULTS

$\bar{Q}$ $\quad T = 16.06\ m^2/d$

$Q_{max}$ $\quad T = 18.53\ m^2/d$

MEAN $T = 17.3\ m^2/d$

## Drawdown Data at GW1D
## Showing Jacob Slopes used for Calculations



Project Sheet:

TES CONSULTING ENGINEERS

Project: TES - GWS PUMP TEST GWID - DRAWDOWN T-CALC

Project No: 1131

Design:

Minutes:

Telephone Log:

Other Record:

Unit:

Sheet No:

Revision No:

Date:

Prepared:

Checked:

Reference:

Page/Action:

JACOBS STRAIGHT LINE FORMULA

$$T = \frac{2.3Q}{4\pi \Delta s}$$

Q = PUMPING RATE ($m^3/d$)

$\Delta s$ = DRAWDOWN PER LOG CYCLE

EARLY TIME

10-100 minutes

$Q = 43.6\ m^3/d$

$\Delta s = 0_m - 0.67_m = 0.67m$

(slope line intersects zero drawdown at 21 minutes, use s = 0 as negative value would not make sense)

$$T = \frac{2.3 \times 43.6\ m^3/d}{4\pi \times 0.67m} = 11.9\ m^2/d$$

LATE TIME

$Q = 48.5\ m^3/d$

$\Delta s = 1.26m - 0.86m = 0.4m$

$$T = \frac{2.3 \times 48.5\ m^3/d}{4\pi \times 0.4} = 22.19\ m^2/d$$

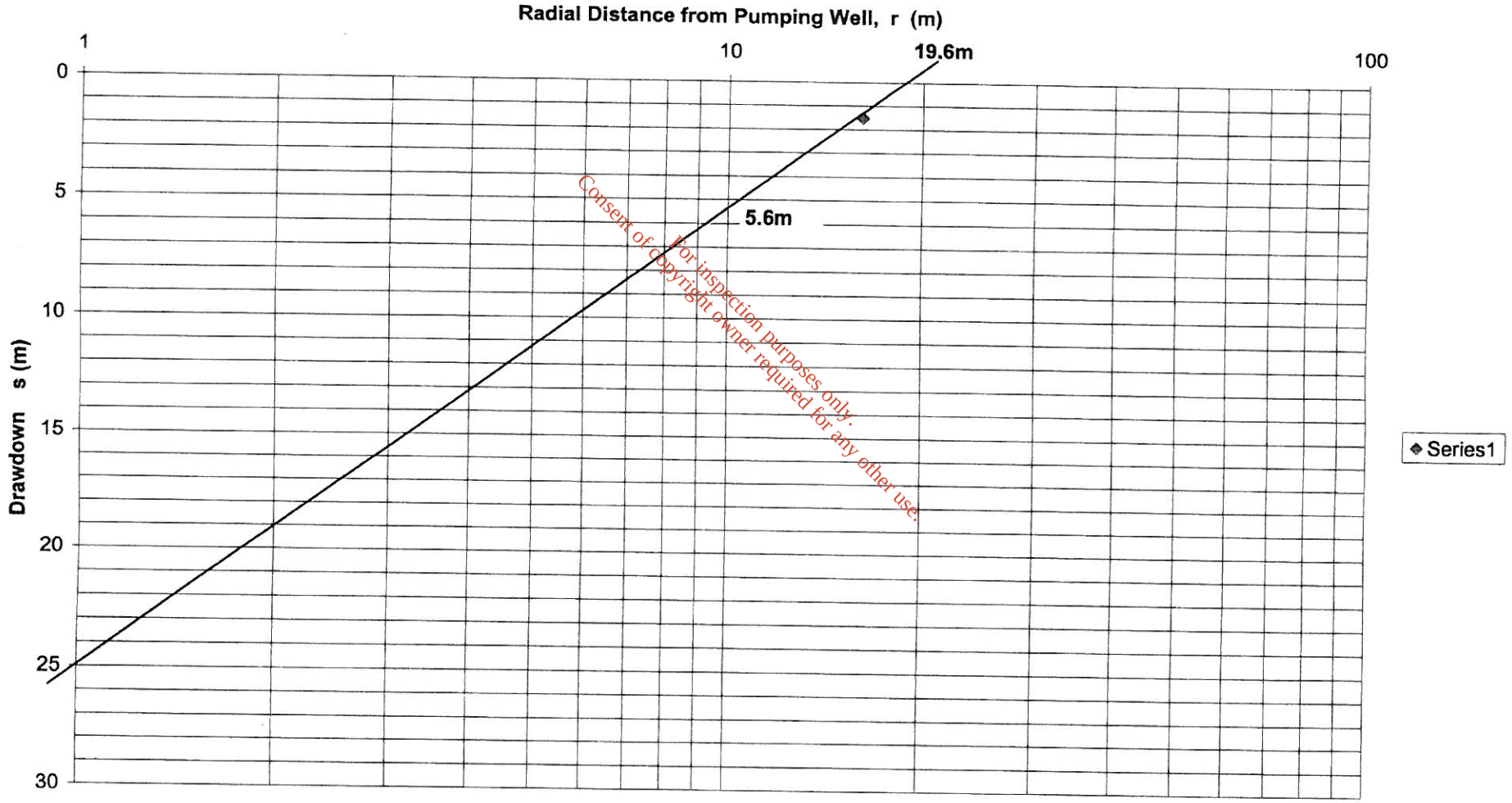
RESULTS

EARLY TIME $T = 11.9\ m^2/d$

LATE TIME $T = 22.19\ m^2/d$

MEAN $T = 17.05\ m^2/d$

## Zero Drawdown analysis using GW6 & GW1D



Project Sheet

TES CONSULTING ENGINEERS

Project: BNM – DREHID LANDFILL

Subject: DISTANCE DRAWDOWN ANALYSIS GW6 + GW1D

Project No: 1131

Design:

Checked:

Telephone Log:

Other Record:

Sheet No: 1

Revision No:

Date:

Prepared:

Checked:

Output Areas:

# JACOBS DISTANCE DRAWDOWN

STEADY S IN GW6 = 25m

$\bar{Q}$ = 49.14 m³/d

$Q_{MAX}$ = 56.68 m³/d

$$T = \frac{2.3Q}{2\pi\Delta s}$$ DISTANCE DRAWDOWN FORMULA

$\Delta s$ = DRAWDOWN PER LOG CYCLE

$\Delta s_{1-10}$ = 25.0m − 5.6m = 19.4 m

$\bar{Q}$ $$T = \frac{2.3 \times 49.14 m^3/d}{2\pi \times 19.4m} = 0.927 m^2/d$$

$Q_{MAX}$ $$T = \frac{2.3 \times 56.68 m^3/d}{2\pi \times 19.4} = 1.069 m^2/d$$



## RESULTS

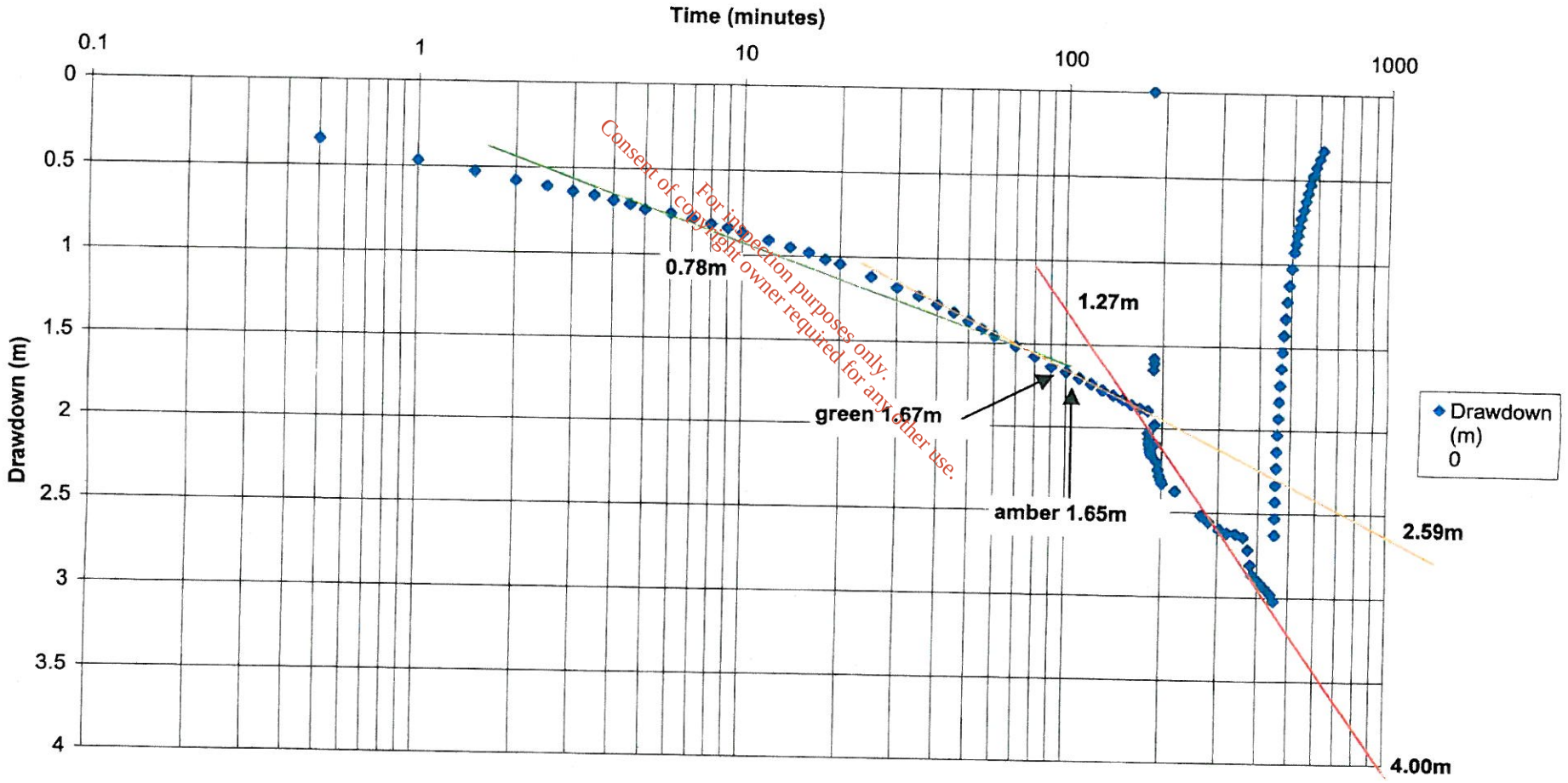
$T = 0.927 m^2/d$

$T = 1.069 m^2/d$

MEAN $T = 0.998 m^2/d$

$T = 1 m^2/d$

**Pump Test Drawdown & Recovery Plot FTC Borehole BH9 Drehid**
**TES PLOT**






TES Consulting Engineers

Project Sheet:

TES

Project: BNM - DREHID LANDFILL

Element: FTC - BH9 PUMP TEST

Project No: 1131

DRAWDOWN DATA T-CALCS

Design / Site Visit / Telephone Log / Other Record: ✓

Sheet No: 1 of 1

Revision No:

Date:

Prepared: KM

Checked:

Reference:

Origin/Action:

JACOB STRAIGHT LINE FORMULA

$$T = \frac{2.3Q}{4\pi\Delta s}$$

Q = PUMPING RATE ($m^3/d$)

$\Delta s$ = DRAWDOWN PER Log CYCLE (m)

① EARLY TIME

$Q = 136.12 m^3/d$

$\Delta s_{10-100} = 1.67m - 0.78m = 0.87m$ (FROM GRAPH)

$$T = \frac{2.3 \times 136.12 m^3/d}{4\pi \times 0.87m} = 28.64 m^2/d$$

② MID TIME

$Q = 170.24 m^3/d$

$\Delta s_{10-100} = 2.59m - 1.65m = 0.94m$ (FROM GRAPH)

$$T = \frac{2.3 \times 170.24 m^3/d}{4\pi \times 0.94} = 33.15 m^2/d$$

③ LATE TIME

$Q = 170.24 m^3/d$

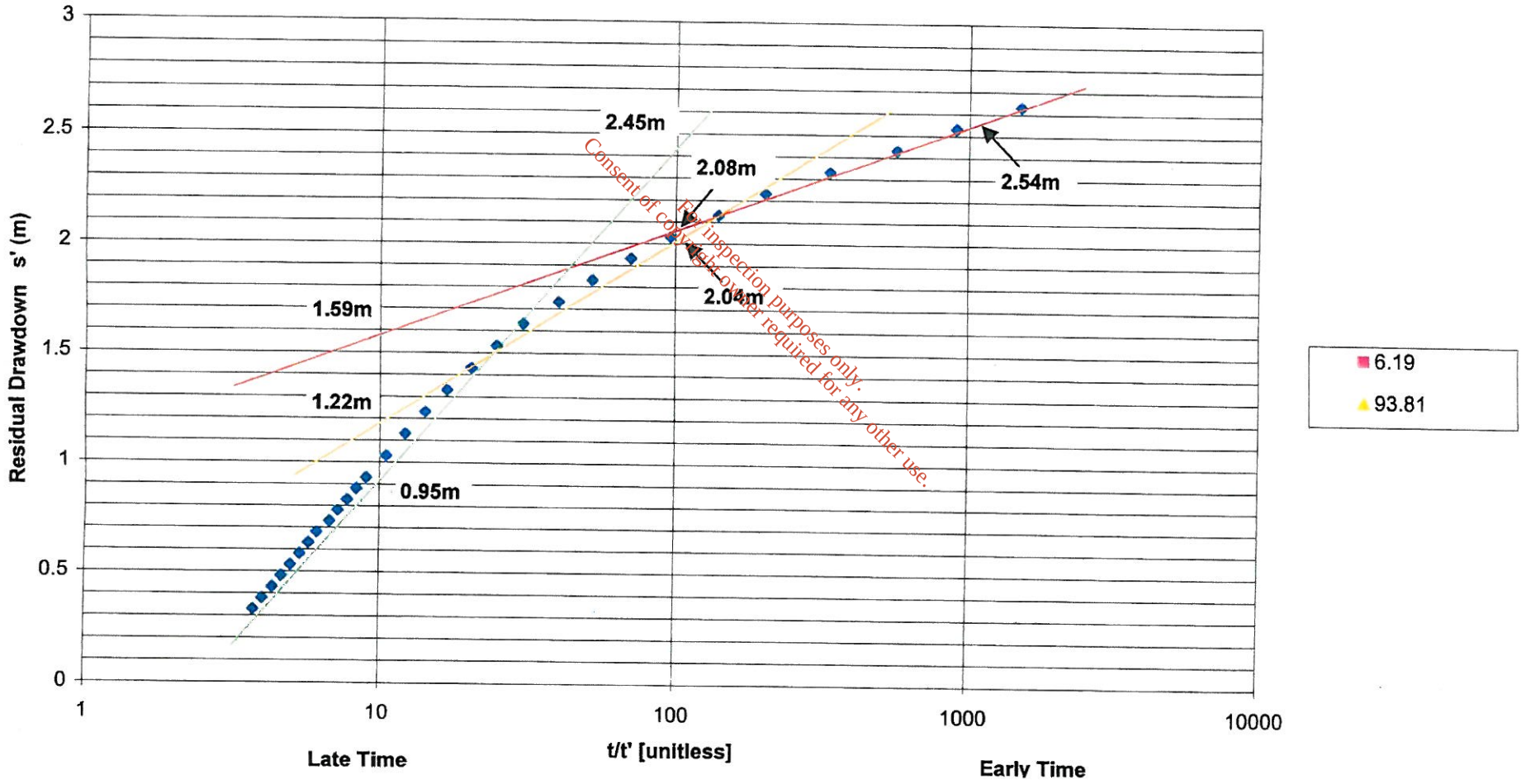
$\Delta s_{100-1000} = 4.00m - 1.27m = 2.73m$ (FROM GRAPH)

$$T = \frac{2.3 \times 170.24 m^3/d}{4\pi \times 2.73} = 11.41 m^2/d$$

RESULTS:

| | | |
|---|---|---|
| EARLY TIME | $T =$ | $28.64 m^2/d$ |
| MID TIME | $T =$ | $33.15 m^2/d$ |
| LATE TIME | $T =$ | $11.41 m^2/d$ |
| MEAN | $T =$ | $24.40 m^2/d$ |

## Recovery Data Plot FTC Borehole BH9 Drehid Showing Jacon Slopes used for Calculations
## TES PLOT






TES Consulting Engineers

Project Sheet

TES

Project: BNM – DRENID LAND FILL

Element: FTC-B49 PUMPTEST

Project No: 1131

RECOVERY DATA T-CALC

Prepared: KM

Subject:

Distribution:

JACOBS STRAIGHT LINE RECOVERY FORMULA

$$T = \frac{2.3Q}{4\pi \times \Delta s'}$$

$\Delta s'$ = change in residual drawdown ($s'$) per log cycle (m)

$Q$ = $\bar{Q}$ (AVERAGE PUMP RATE FOR TEST) ($m^3/d$)

48,145 l over 450 minutes pumping (FTC DATA SHEET)

$$\frac{48,145 l}{450 min} = 106.99 l/min = 154.06 m^3/d$$

LATE TIME

$\Delta s' = 2.45_m - 0.95_m = 1.5m$

$$T = \frac{2.3 \times 154.06 m^3/d}{4\pi \times 1.5m} = 18.79 m^2/d$$

MID TIME

$\Delta s' = 2.04_m - 1.22_m = 0.82m$

$$T = \frac{2.3 \times 154.06 m^3/d}{4\pi \times 0.82} = 34.40 m^2/d$$

EARLY TIME

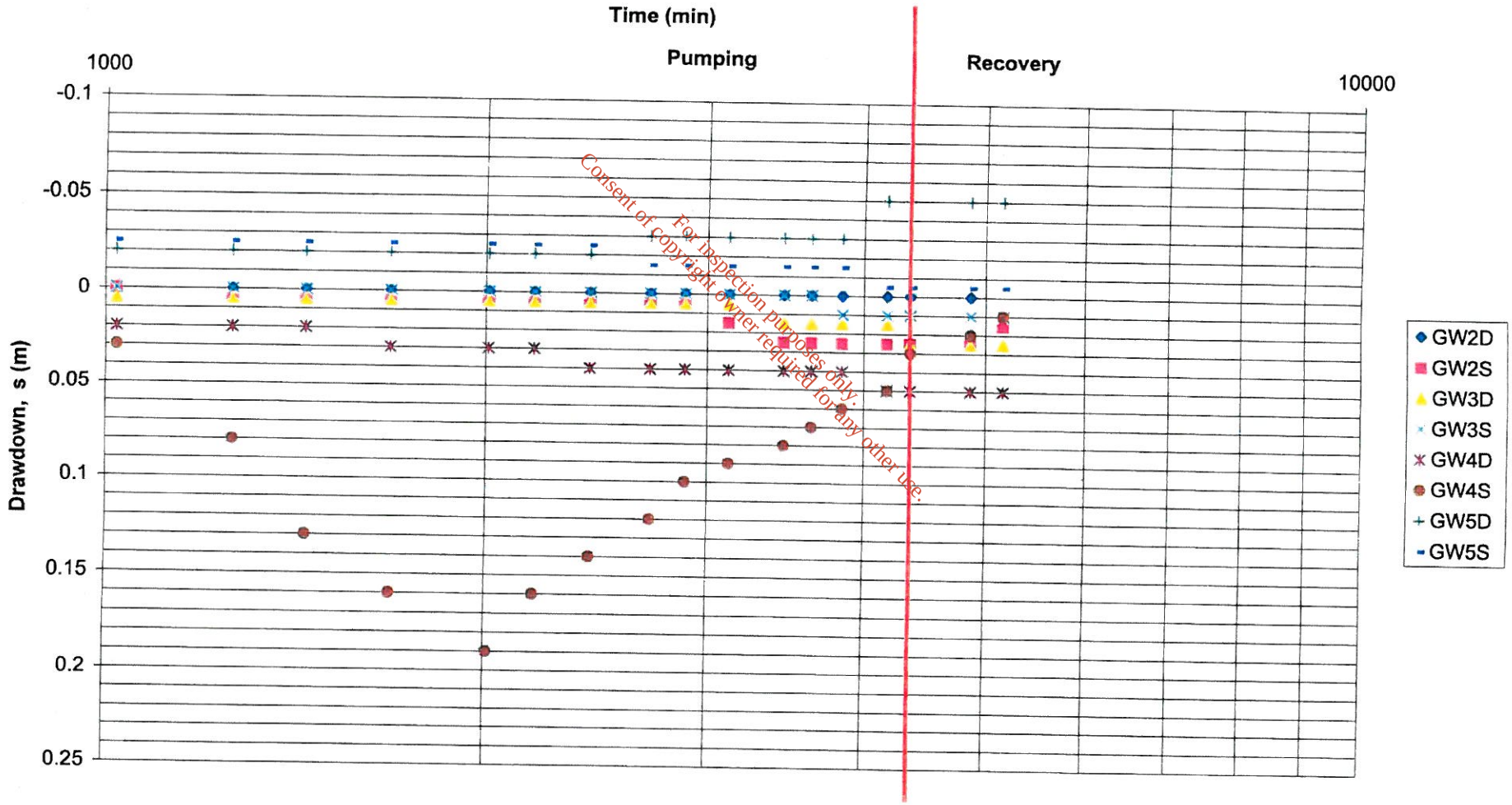
$\Delta s' = 2.64_m - 2.08_m = 0.46m$

$$T = \frac{2.3 \times 154.06}{4\pi \times 0.46} = 61.3 m^2/d$$

RESULTS:

| | |
|---|---|
| EARLY TIME | $T = 61.3 m^2/d$ |
| MID TIME | $T = 34.40 m^2/d$ |
| LATE TIME | $T = 18.79 m^2/d$ |
| MEAN | $T = 38.16$ |

## Drawdown at Piezometers Drehid Pump Test



# APPENDIX 2.4.9
# Calculation Sheets for estimation of Bedrock Permeability

Project Sheet:

TES

Project: BNM - DRUMLID LANDFILL

Job No: 1131

Sheet: BEDROCK K - ESTIMATION

Sheet No: 1 of 2

Revision No:

Date:

Prepared: KM

Checked:

References

Calculations

# ESTIMATION OF PERMEABILITY FROM TRANSMISSIVITY VALUES.

TRANSMISSIVITY RANGE 2 - 16 $m^2/d$

$T = KD$ OR $K = \frac{T}{D}$

K = PERMEABILITY (m/day)

D = THICKNESS OF THE AQUIFER (m)

LENGTH OF WELL SCREEN (SB1) = 8.8m

DEPTH OF WATER IN BOREHOLE

GROUND LEVEL = 84.737 mOD

BASE of BOREHOLE (84.737 - 36.8) = 47.94mOD

SWL 16/1/03 = 83.782mOD

BASE OF BOREHOLE = 47.94 mOD

WATER COLUMN = 35.84 m (SATURATED THICKNESS)

## POSSIBLE VALUES FOR D

Length of Screen = 8.8m

Water Column in Borehole = 35.84m

LIKELY PORTION OF LA AQUIFER WHERE K IS HIGHEST OR THE TOP 50m IS A REASONABLE ESTIMATE.

Project Sheet:

TES
CONSULTING ENGINEERS

Project: BNM - ORCHID LANDFILL
Client: BEDROCK K-ESTIMATION
Project No: 1131

Task: ✓ | Design | Minutes | Telephone Log | Other Record
Sheet No: 2 of 2
Revision No
Date
Prepared: KM
Checked

Reference | Calculations

$T = 2 m^2/d$

SCREEN LENGTH: $K = 2 m^2/d \div 8.8 m = 2.27 \times 10^{-1} m/d$ or $2.6 \times 10^{-6} m/s$

SATURATED THICKNESS: $K = 2 m^2/d \div 358 m = 5.58 \times 10^{-3} m/d$ or $6.45 \times 10^{-7} m/s$

TOP 50m: $K = 2 m^2/d \div 50 m = 4.0 \times 10^{-2} m/d$ or $4.63 \times 10^{-7} m/s$

ESTIMATED BEDROCK $K = 4.63 \times 10^{-7}$ to $2.6 \times 10^{-6} m/s$
IF $T = 2 m^2/d$

---

$T = 16 m^2/d$

SCREEN LENGTH: $K = 16 m^2/d \div 8.8 m = 1.82 m/d$ or $2.1 \times 10^{-5} m/s$

SATURATED THICKNESS: $K = 16 m^2/d \div 358 m = 4.46 \times 10^{-2} m/d$ or $5.2 \times 10^{-6} m/s$

TOP 50m: $K = 16 m^2/d \div 50 m = 3.2 \times 10^{-1} m/d$ or $3.7 \times 10^{-6} m/s$

ESTIMATED BEDROCK $K = 3.7 \times 10^{-6}$ to $2.1 \times 10^{-5} m/s$
IF $T = 16 m^2/d$.

---

# APPENDIX 2.4.10
# Aquifer Throughput Calculations and Methodology

Project Sheet

TES
CONSULTING ENGINEERS

Project: BMM - Derelict Landfill
Subject: Aquifer Throughput Calcs
Project No: 1131
Design
Minutes
Telephone Log
Other Records
Tick: ✓
Sheet No: 1 of 2
Revision No
Date
Prepared
Checked
Reference
Queries/Action

FLOW PER UNIT WIDTH $Q = TL$

FLOW BENEATH FOOTPRINT $Q = WTL$

WHERE

$Q$ = FLOW IN $(M^3/d)$

$T$ = TRANSMISSIVITY IN $(M^2/d)$

$L$ = HYDRAULIC GRADIENT - (UNITLESS)

$W$ = WIDTH OF AQUIFER CONSIDERED IN (M)

$T$ FOR SITE SHOWN TO BE IN APPROXIMATE RANGE OF 2 - 16 $M^2/d$ WITH LOWER VALUES PROBABLY MORE REPRESENTATIVE

$L$ HYDRAULIC GRADIENTS FROM FIGURE 2.4.7 (AFTER PAGE 28 IN EIS) RANGE FROM 0.0012 TO 0.0039, WITH $L$ MORE LIKELY CLOSER TO 0.0012 IN FOOTPRINT FLAT AREA OF BOG RATHER THAN FRINGES WHERE $L$ SLIGHTLY HIGHER.

PRECAUTIONARY VALUE TAKEN AS 0.0025 (HIGHER THAN EXPECTED, FACTOR SAFETY = 2)

$W$ FOR LANDFILL FOOTPRINT IS THE MAXIMUM LENGTH SECTION ACROSS THE FOOTPRINT

462 m x 460m DIMENSIONS

PYTHAGORAS ⇒ DIAGONAL SECTION ACROSS FOOTPRINT = 652 m.

Project Sheet:

TES
CONSULTING ENGINEERS

Project: BNM - DREHID LANDFILL
Element: AQUIFER THROUGHPUT CALCS
Project No: 1131
Task: Design / Man Hrs / Time Sheet Log / Other Record
Sheet No: 2 of 2
Revision No:
Date:
Prepared:
Checked:

References

Calculation

$Q = WTi$

① Let $T = 2 m^2/d$
$i = 0.0025$
$W = 652 m$

$Q = 652m \times 2m^2/d \times 0.0025$
$= 3.26 m^3/d$

② Let $T = 16 m^2/d$
$i = 0.0025$
$W = 652 m$

$Q = 652 \times 16 m^2/d \times 0.0025$
$= 26.08 m^3/d$

AQUIFER THROUGHPUT BENEATH FOOTPRINT RANGES 3.26 to 26.08 $m^3/d$ WITH LOWER VALUE OF 3.26 $m^3/d$ MORE PROBABLE