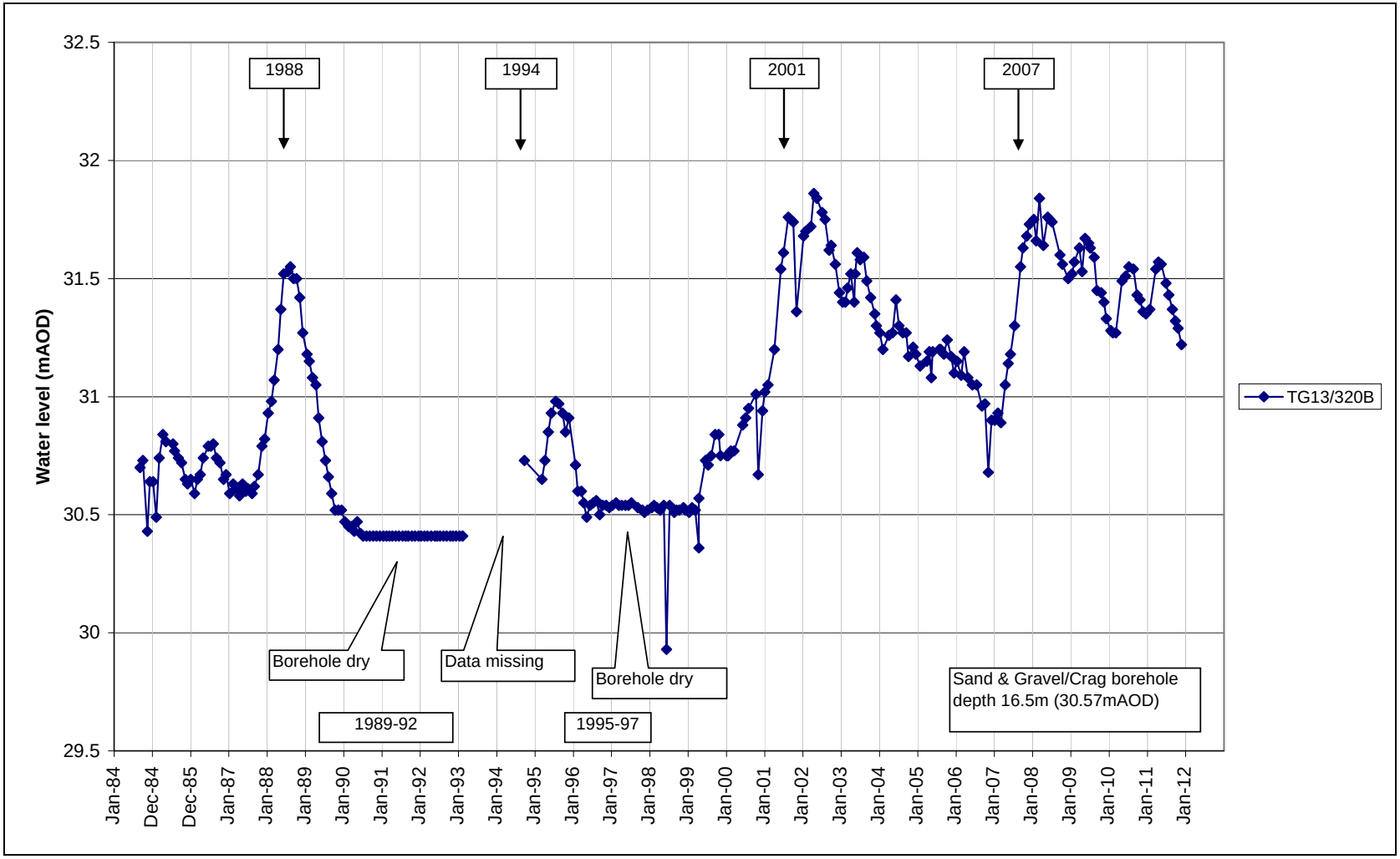


Figure E1 – Groundwater levels in a Sand & Gravel/Crag observation borehole (TG13/320B) near Itteringham, to the north of Aylsham (TG 1304 3215)

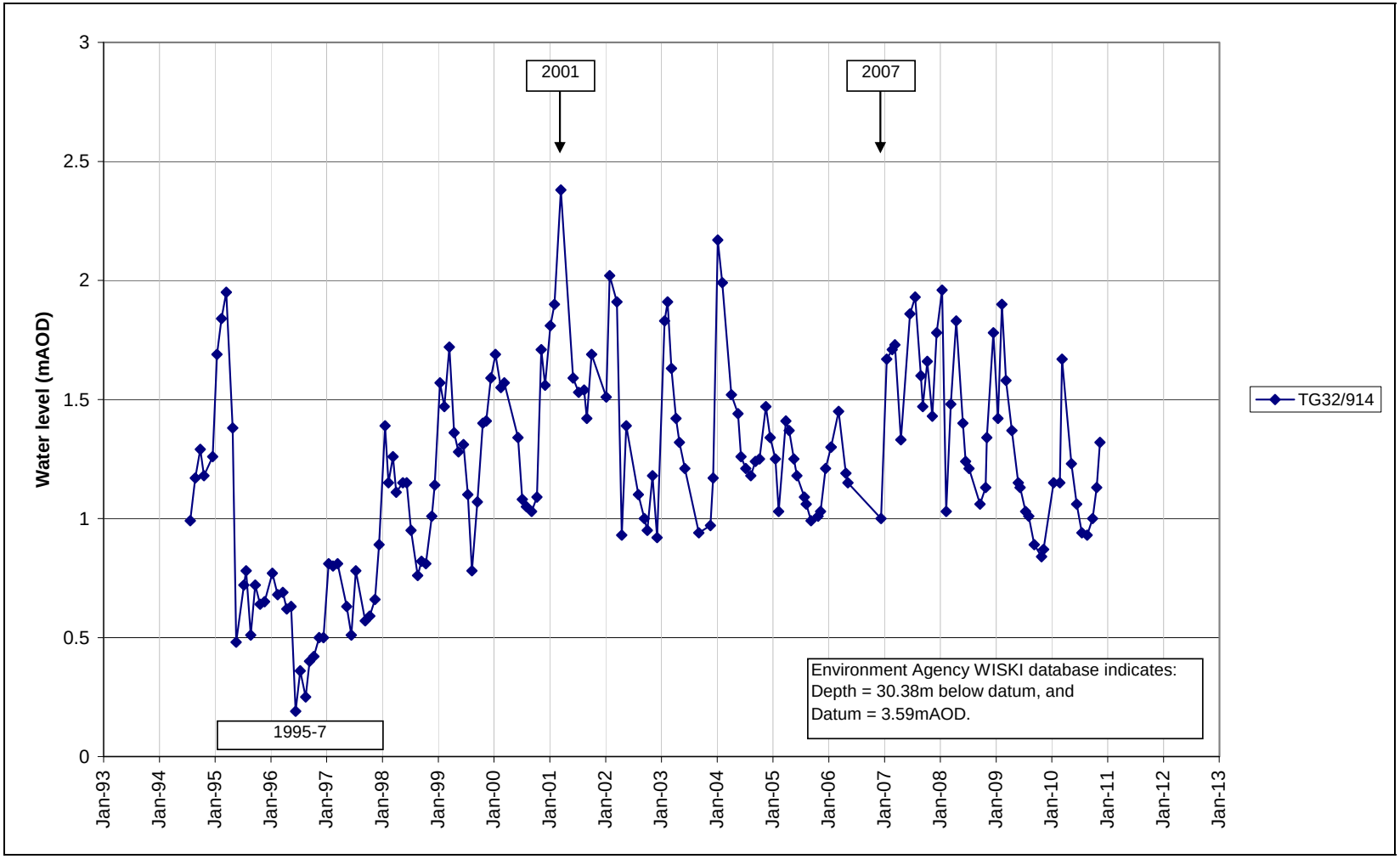


Figure E2 – Groundwater levels in a Crag observation borehole (TG32/914) about 800m east of Catfield on New Road (TG 39378 21796)

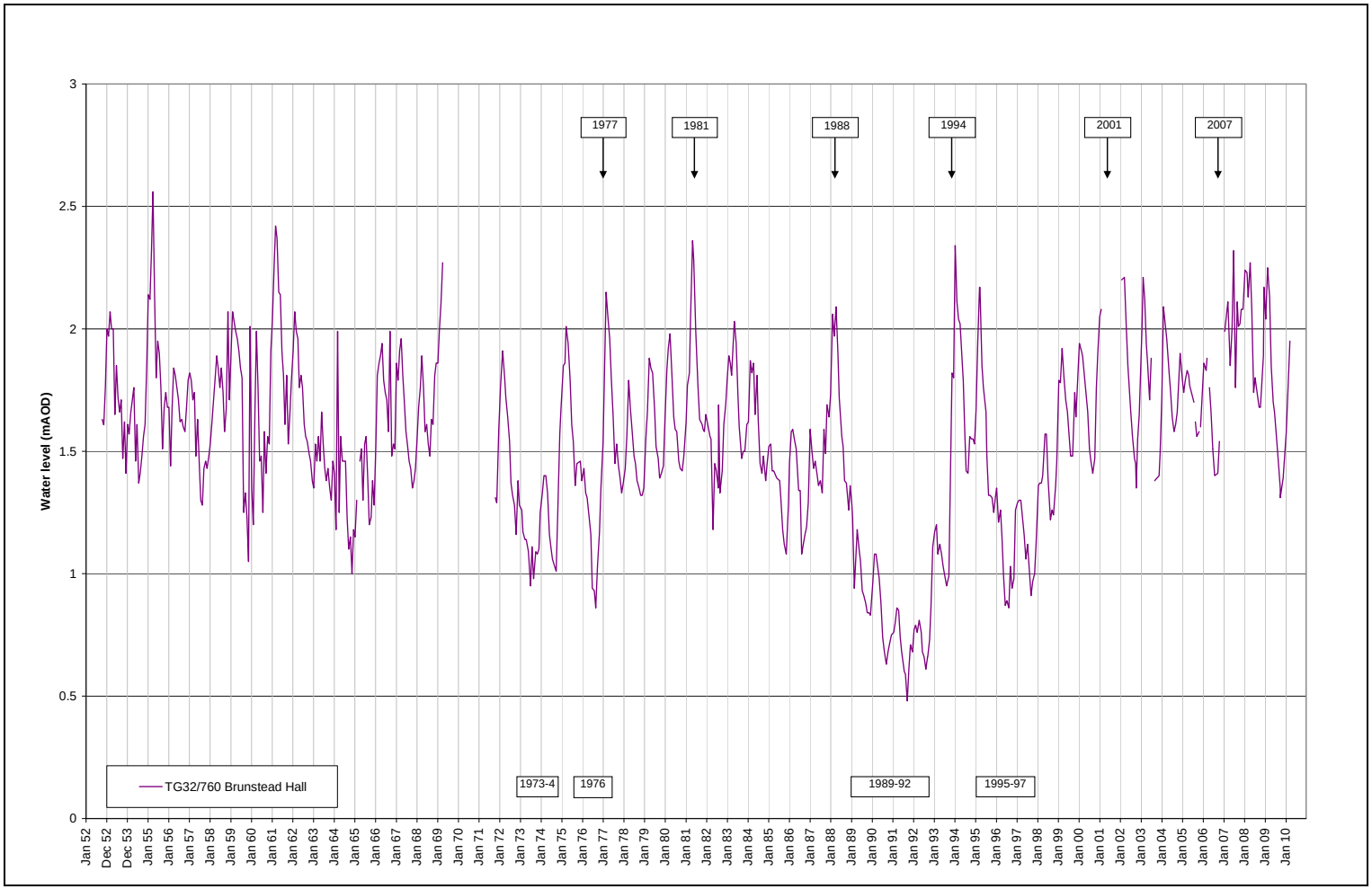


Figure E3 – Groundwater levels in a Chalk observation borehole (TG32/760) to the north of Stalham (TG 3701 2681). Note the gap in data during 2001 is observed in many hydrographs and is due to the Foot & Mouth outbreak which prevented monitoring in many places during the period March – autumn 2001.

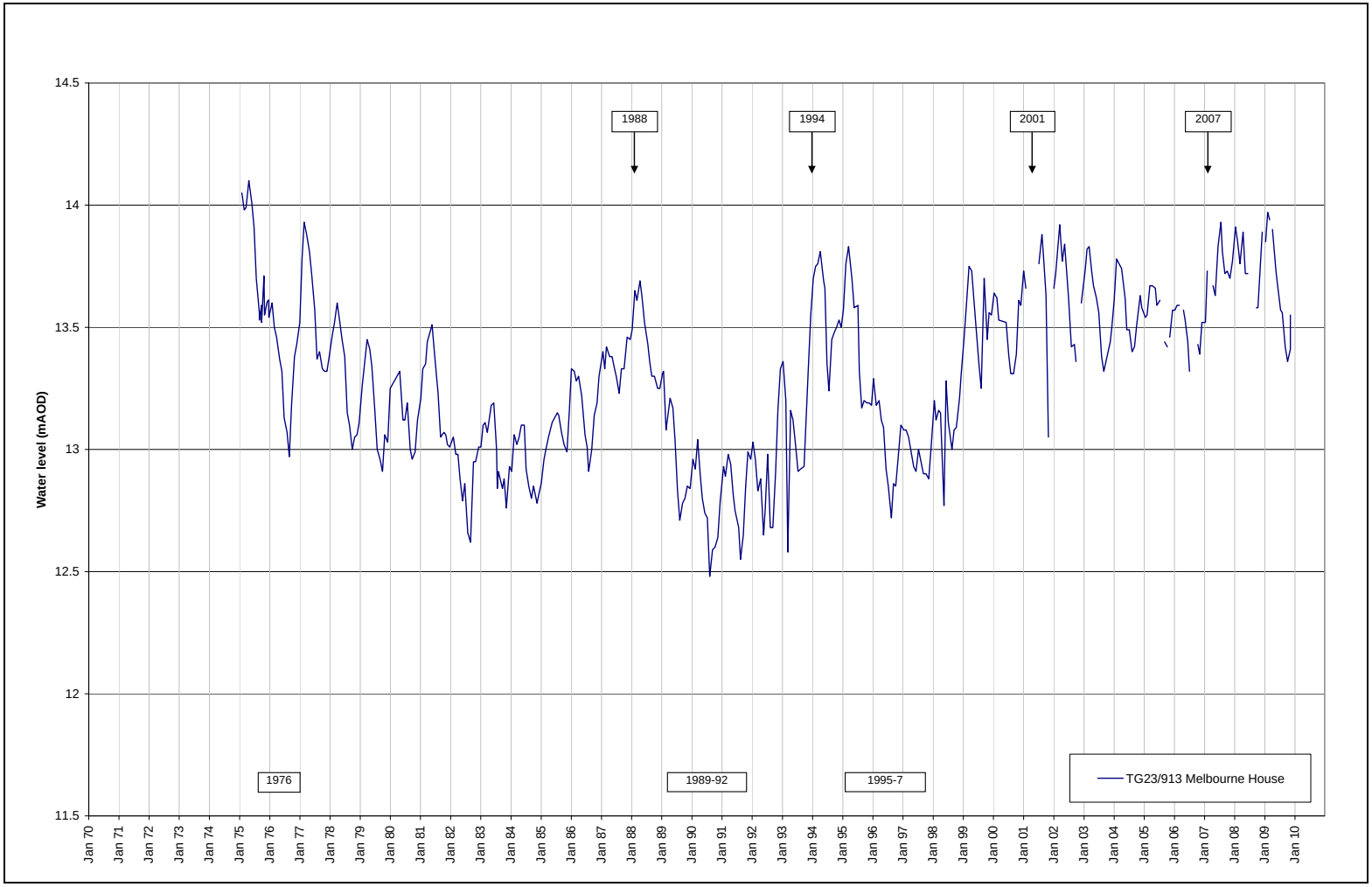


Figure E4 – Groundwater levels in a Chalk observation borehole (TG32/913) at North Walsham (TG 2931 3103)

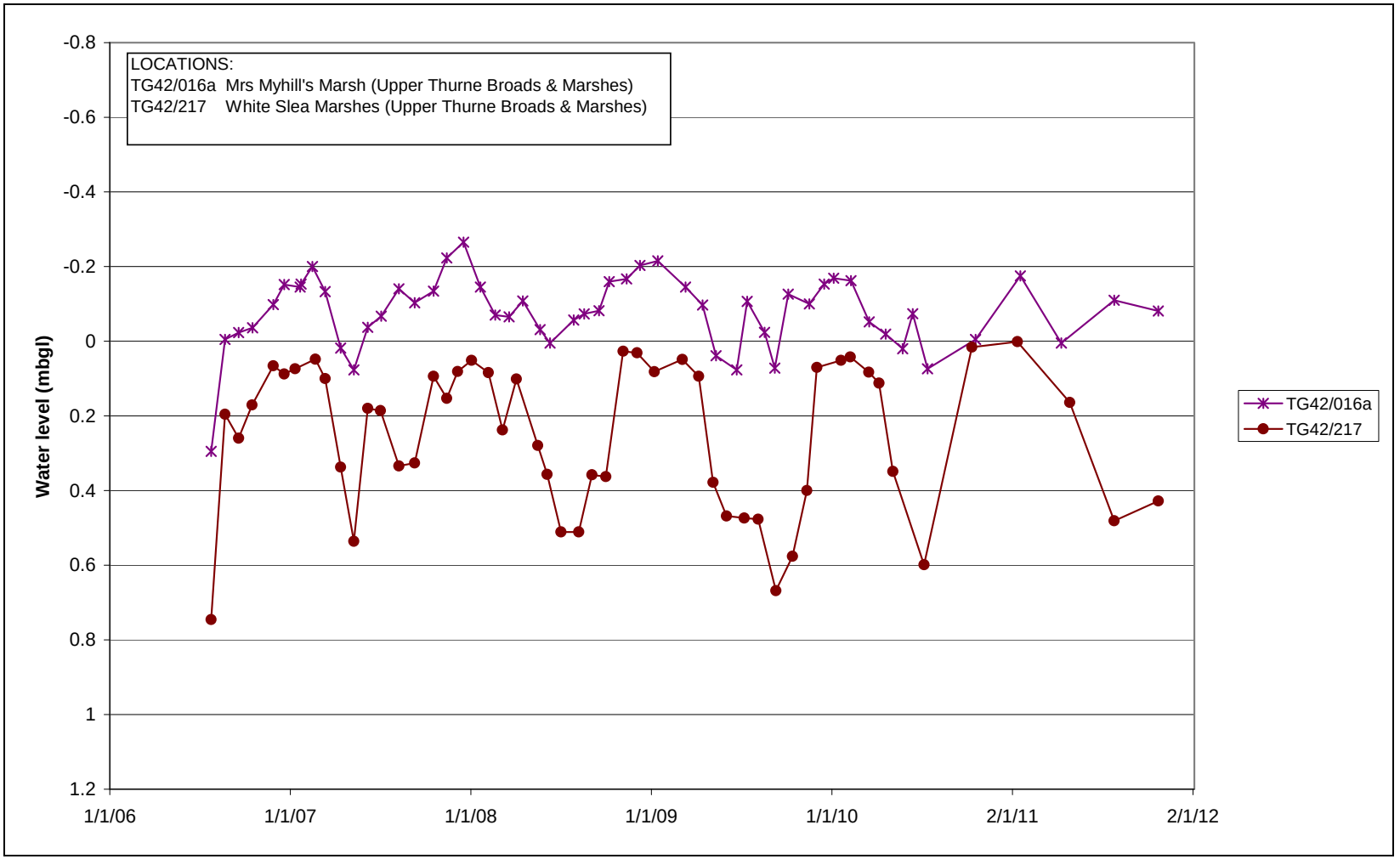


Figure E5 – Groundwater levels in some dipwells in Upper Thurne Broads & Marshes SSSI

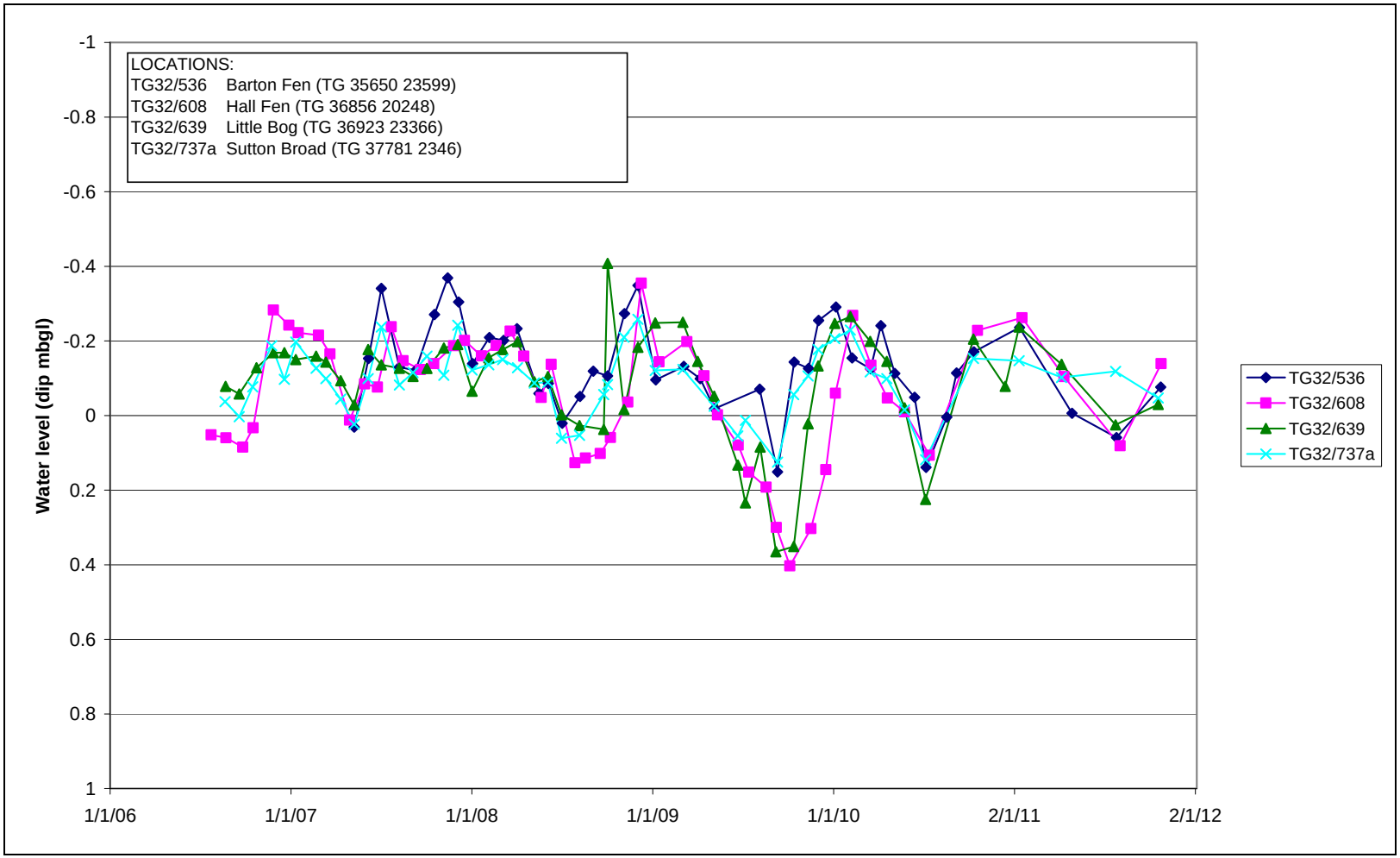


Figure E6 – Groundwater levels in some dipwells in Ant Broads & Marshes SSSI, other than at Catfield Fen

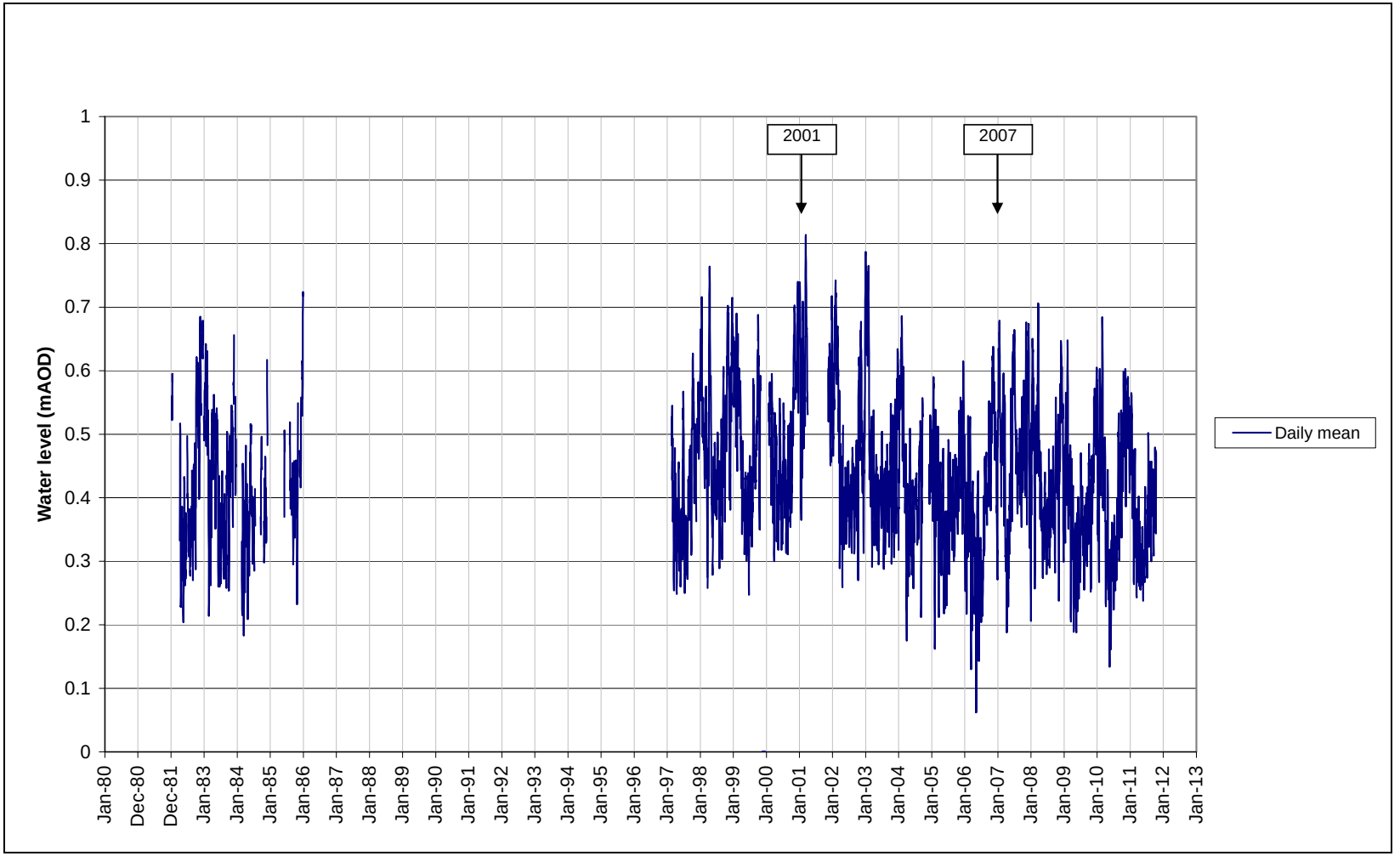


Figure E7 – Mean daily water levels at Barton Broad (Station no. T340903)

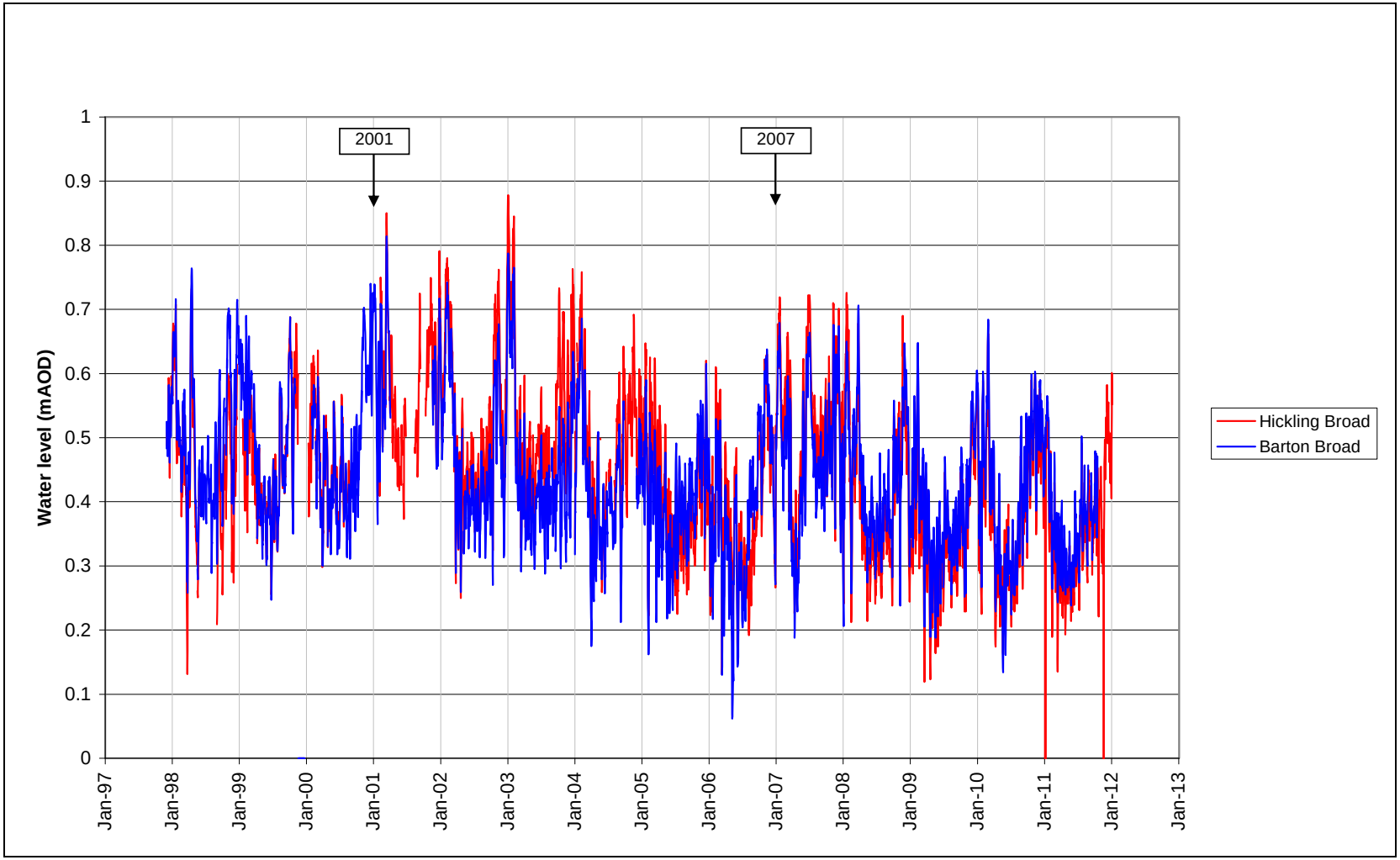


Figure E8 – Mean daily water levels at Barton Broad (Station no. T30903) and at Hickling Broad (Station no. T341001)

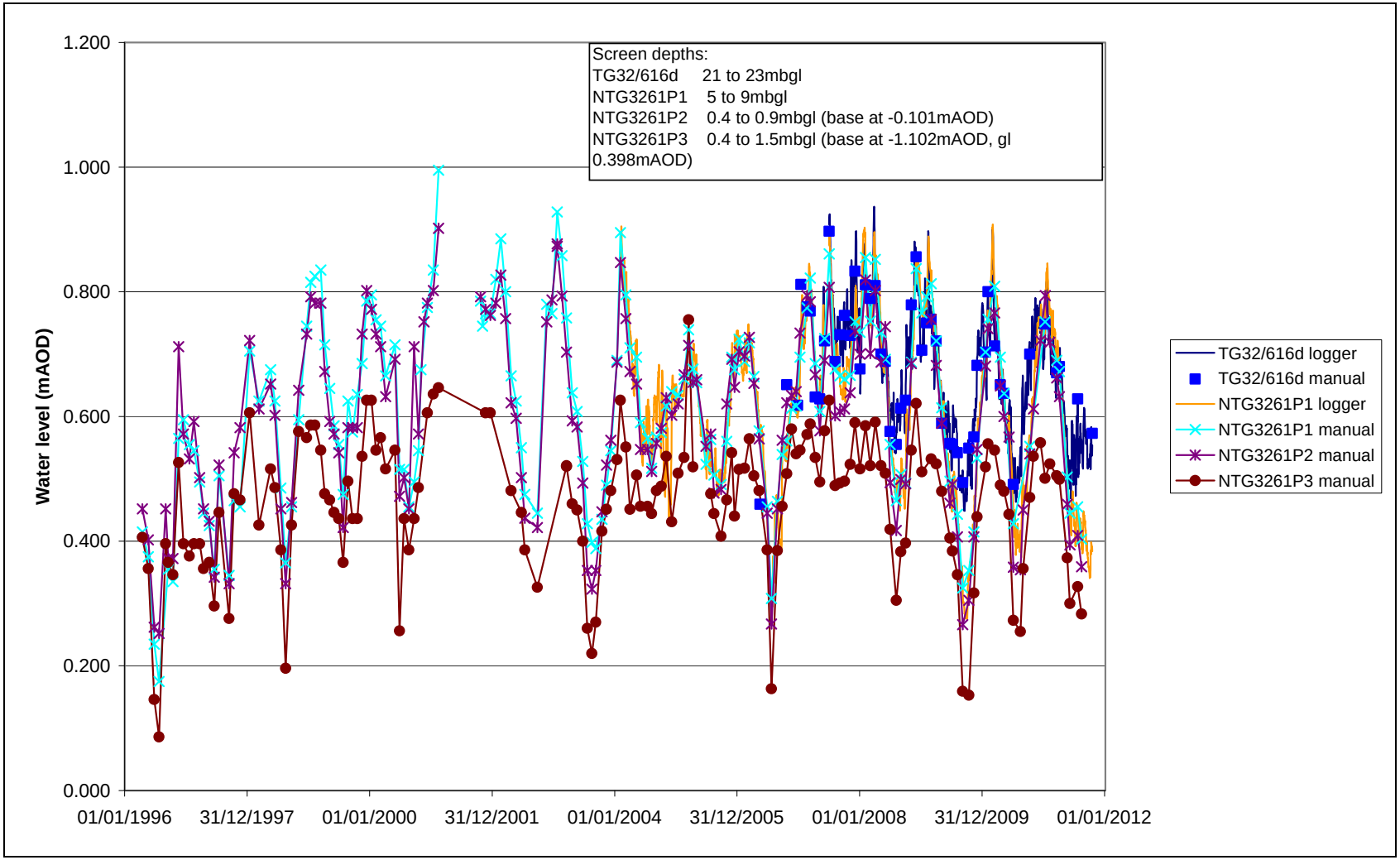


Figure E9 – Groundwater levels in the NW part of Catfield Fen

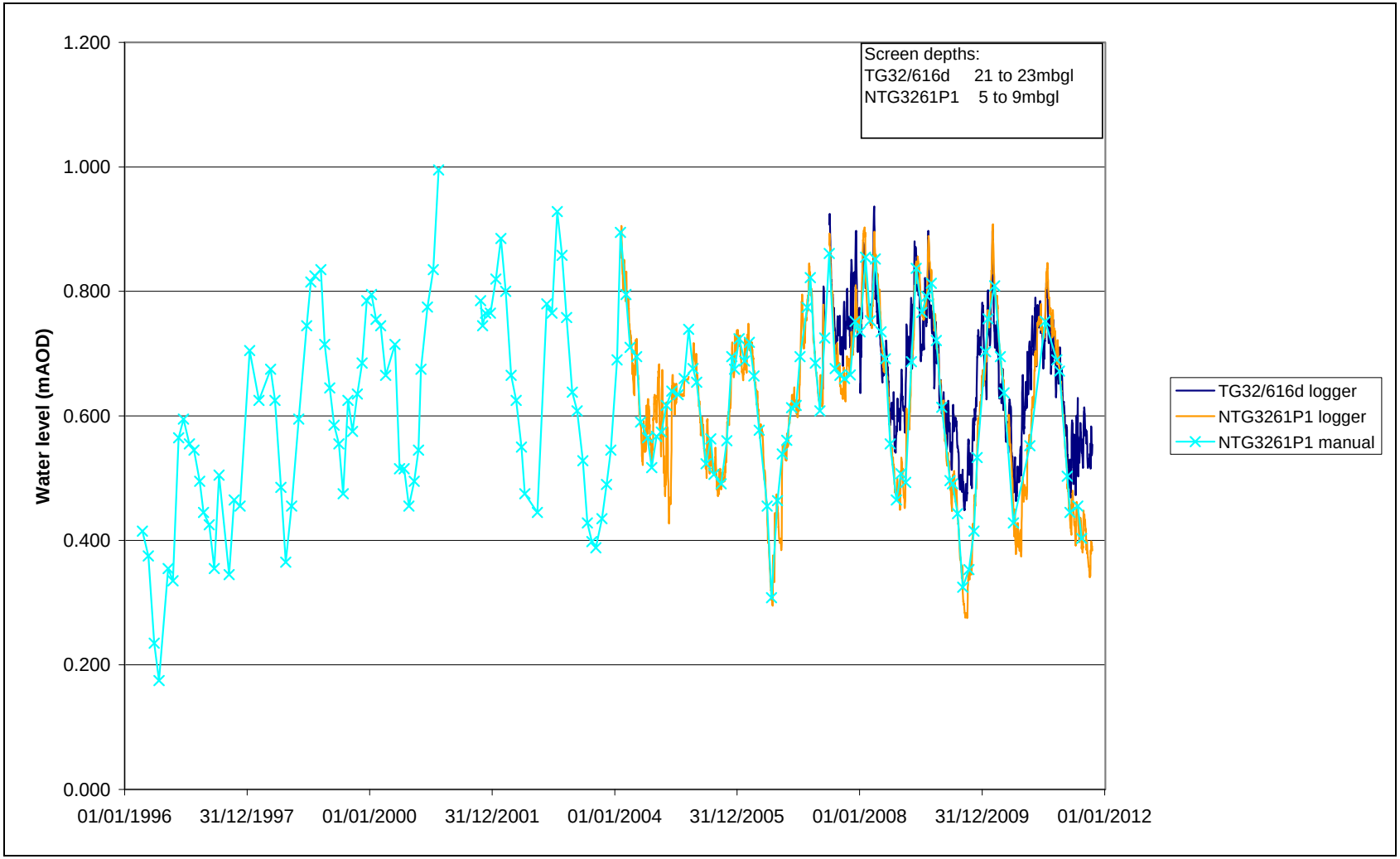


Figure E10 – Groundwater levels in two boreholes in the NW corner of Catfield Fen

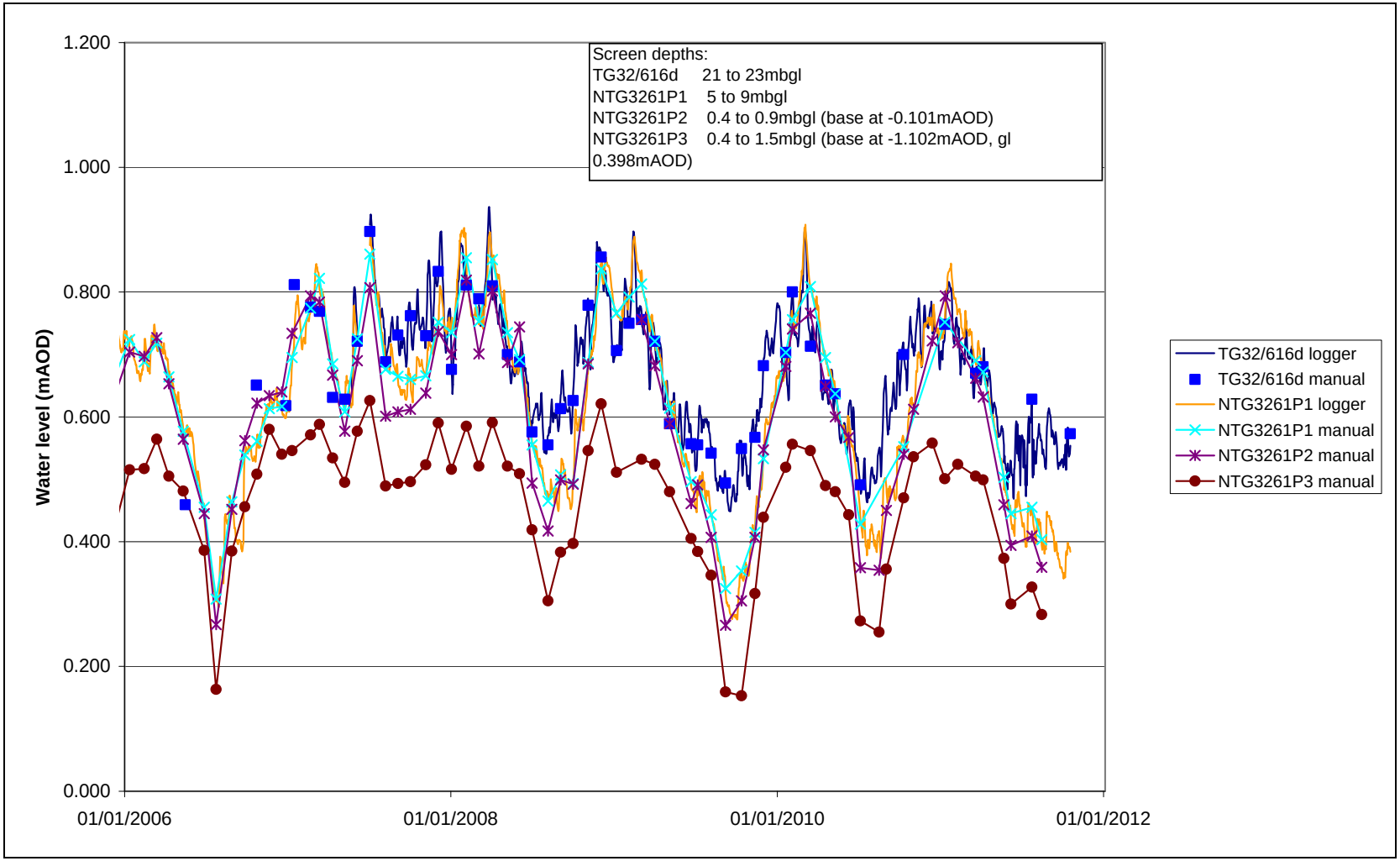


Figure E11 – Groundwater levels in boreholes in the NW corner of Catfield Fen, 2006 – 2011

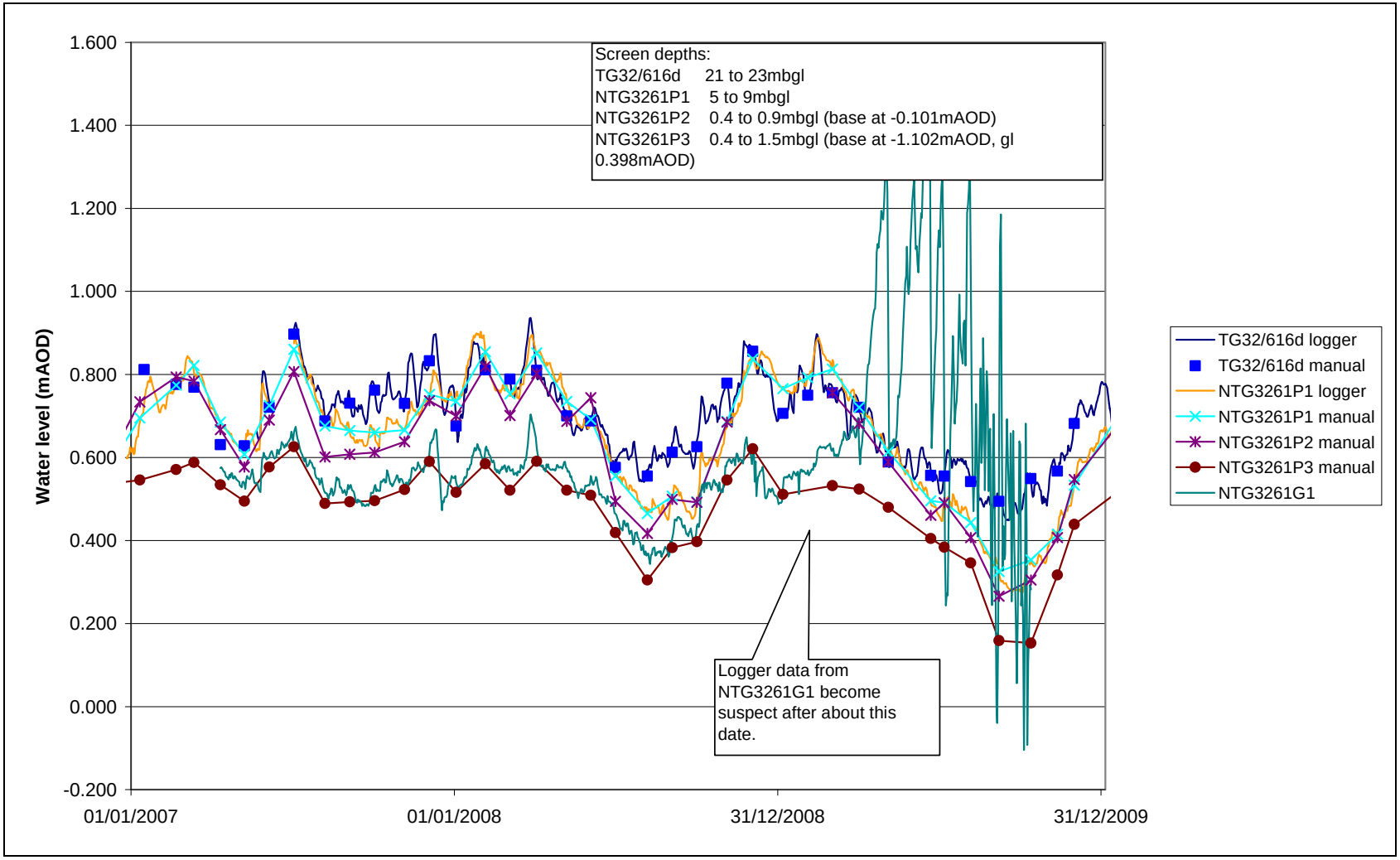


Figure E12 – Comparison of groundwater levels in boreholes in the NW corner of Catfield Fen with dyke water levels in the internal system at NTG3261G1

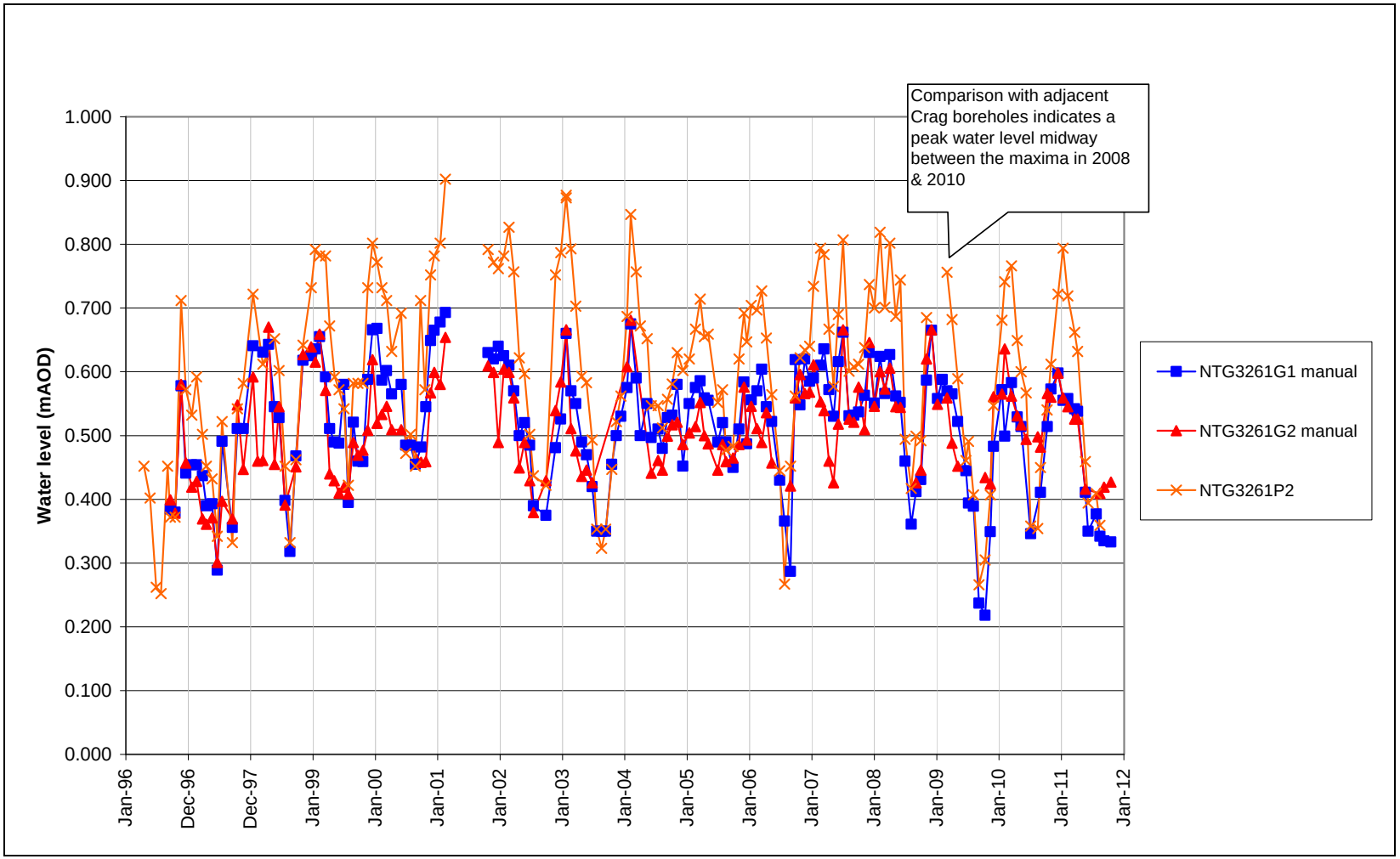


Figure E13 – Comparison of groundwater levels in the shallow borehole NTG3261P2 in the NW corner of Catfield Fen with dyke water levels in the internal and external systems

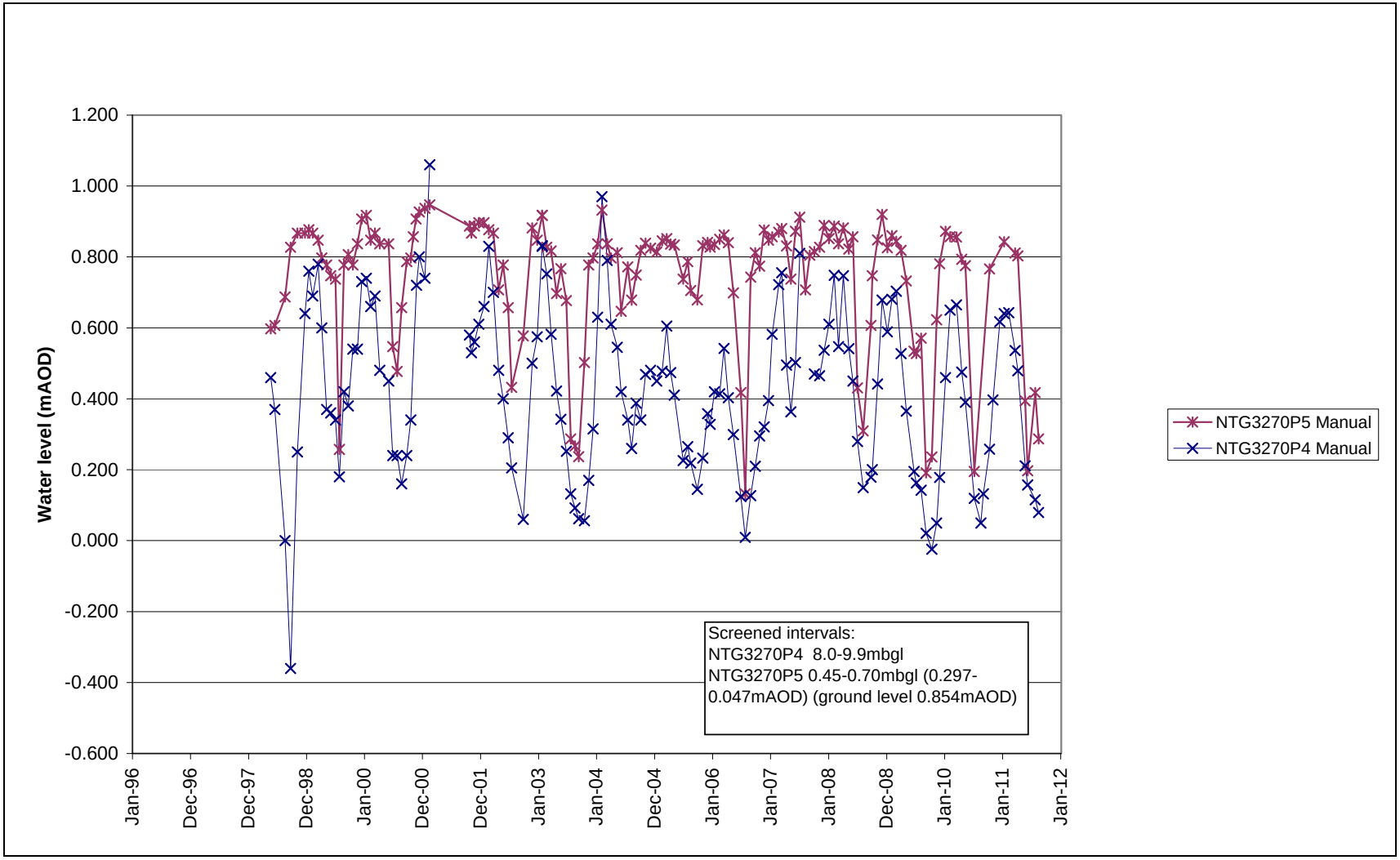


Figure E14 – Comparison of groundwater levels (manual data) in two boreholes at the SE corner of Catfield Fen

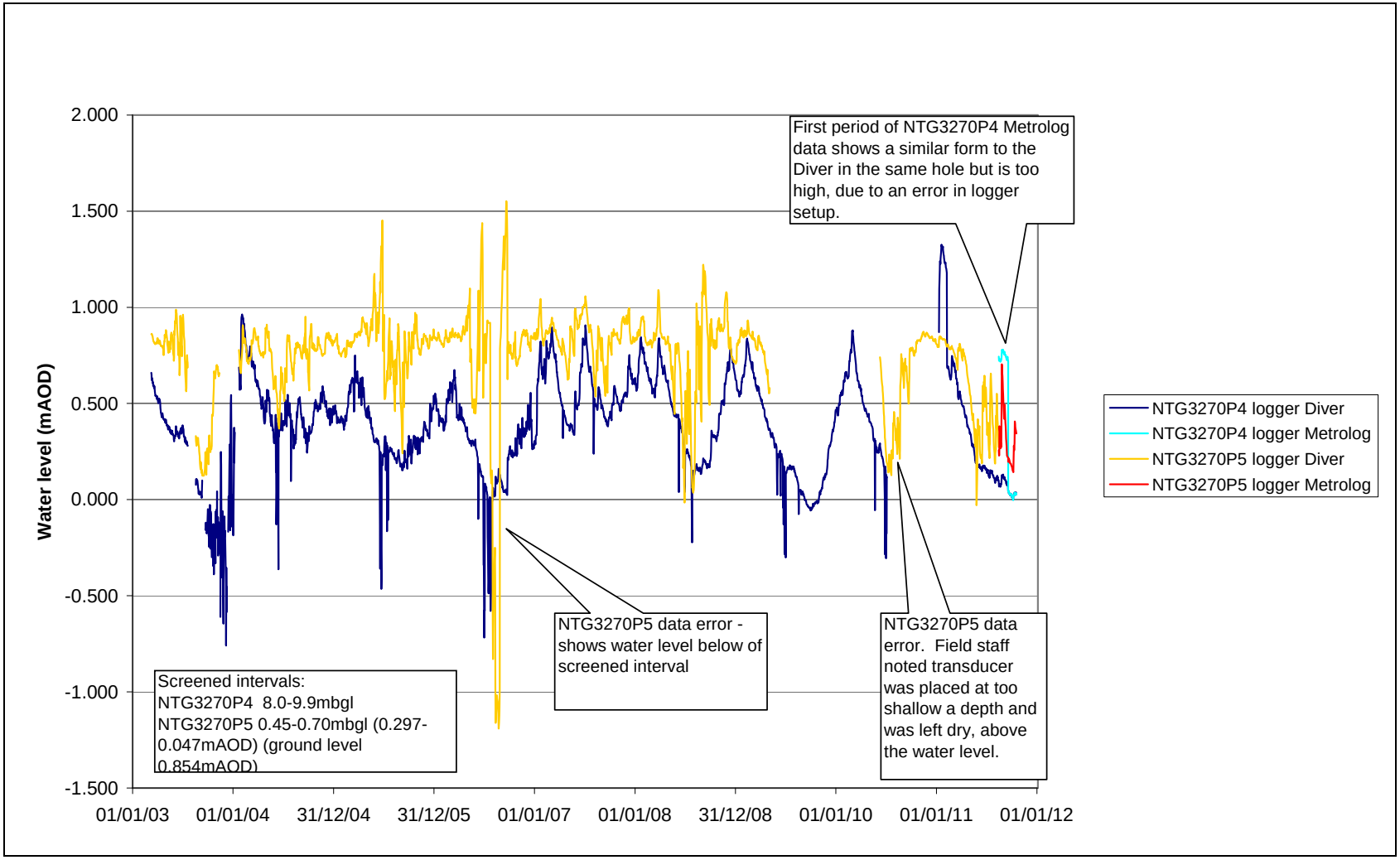


Figure E15 – Groundwater levels (logger data) in two boreholes at the SE corner of Catfield Fen

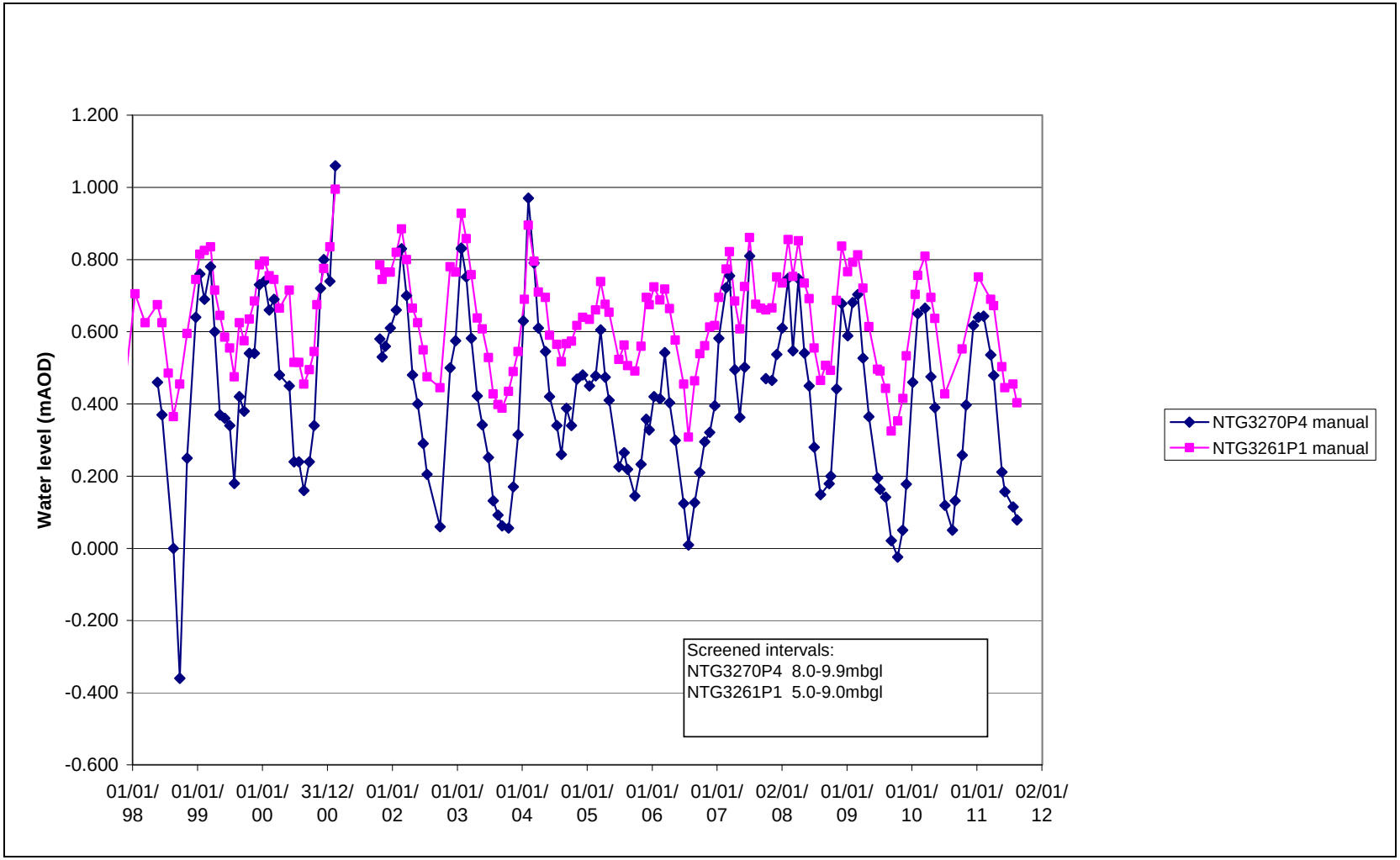


Figure E16 – Comparison of the groundwater levels in two Crag boreholes of similar depths at the SE (NTG3270P4) and NW (NTG3261P1) corners of Catfield Fen

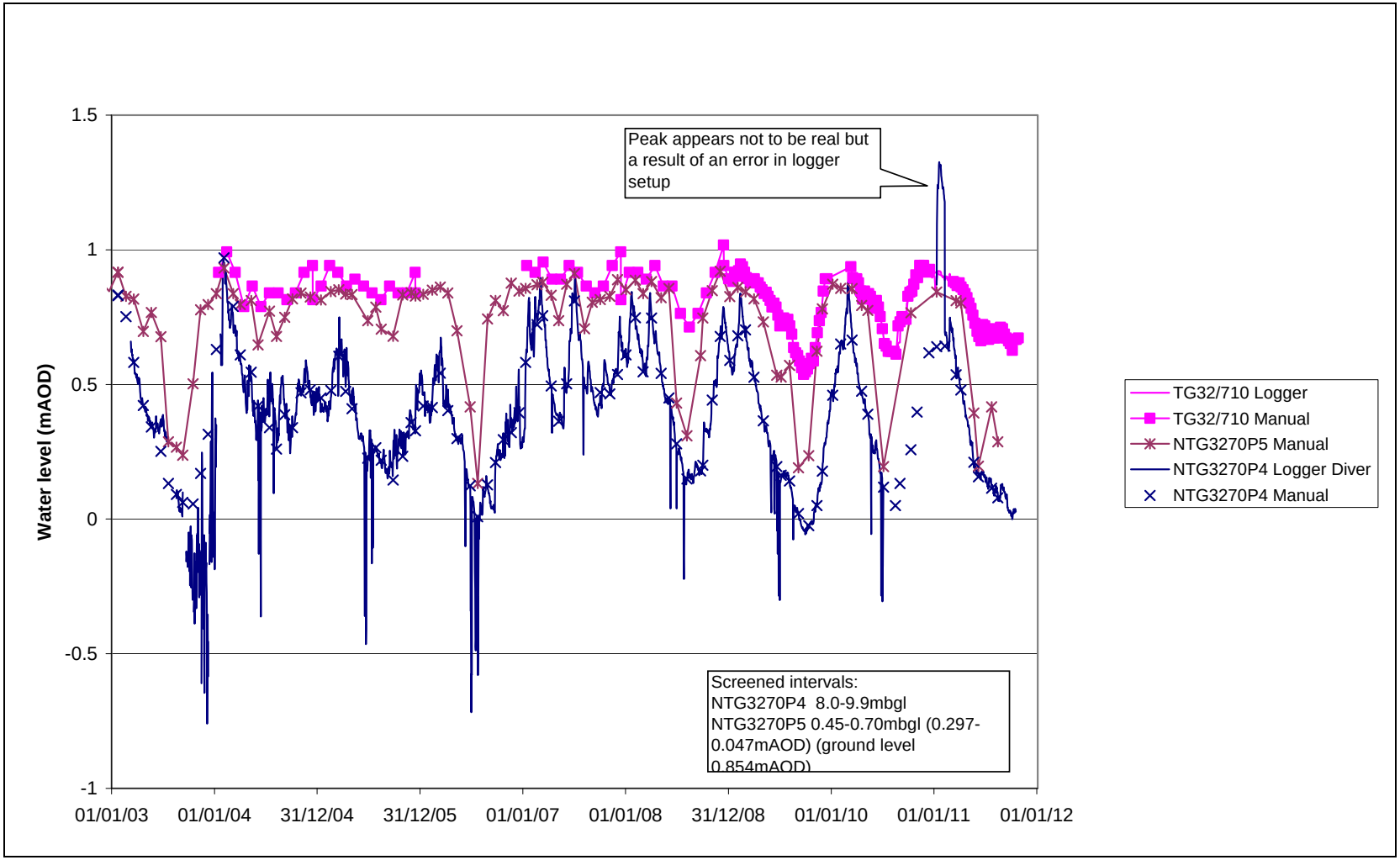


Figure E17 – Comparison of the groundwater levels in two boreholes at the SE corner of Catfield with dyke water levels in the eastern catchwater drain at TG32/710 to the NNE

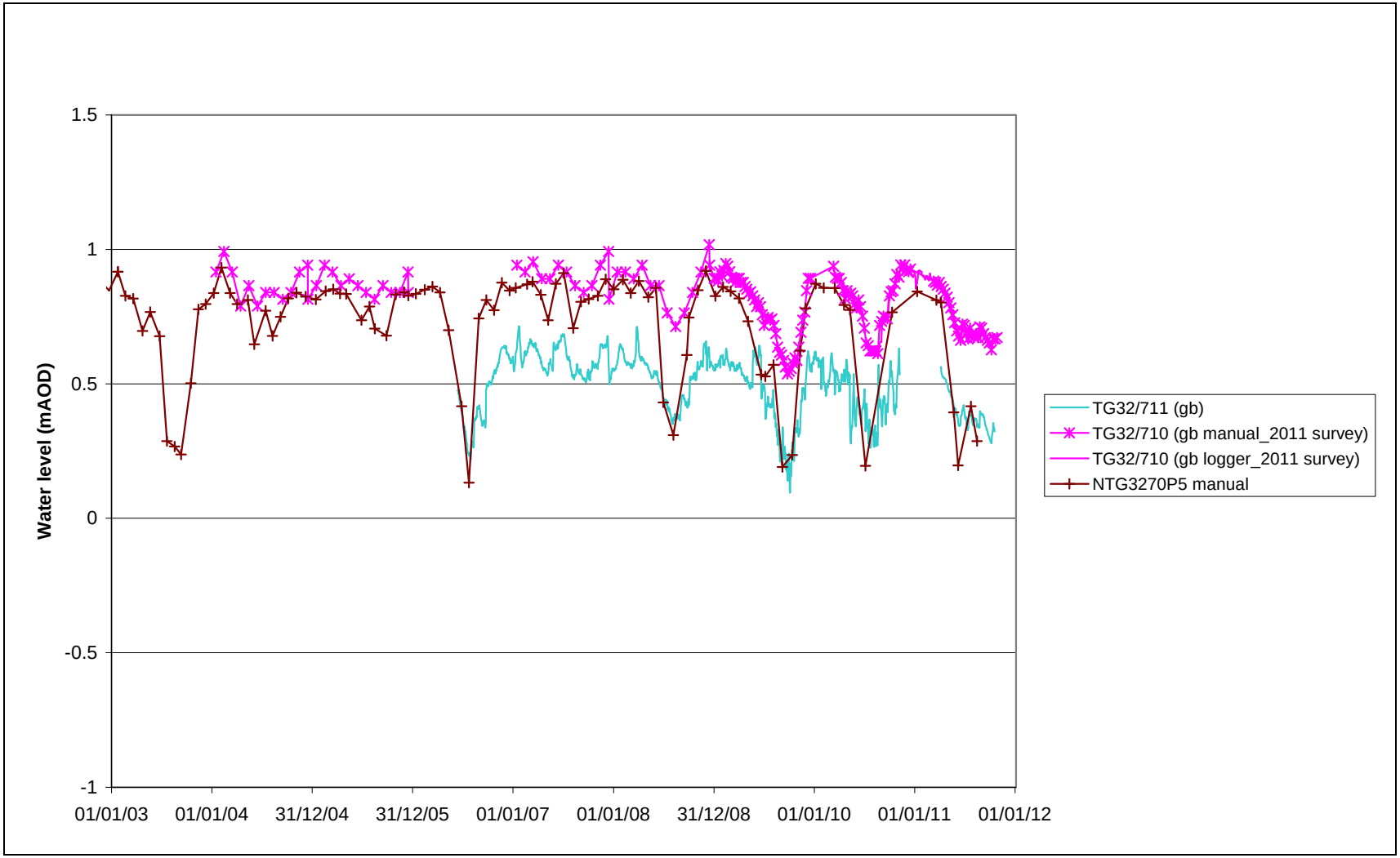


Figure E18 – Comparison of dyke water levels with shallow groundwater levels at the SE corner of Catfield Fen, and to the east of it

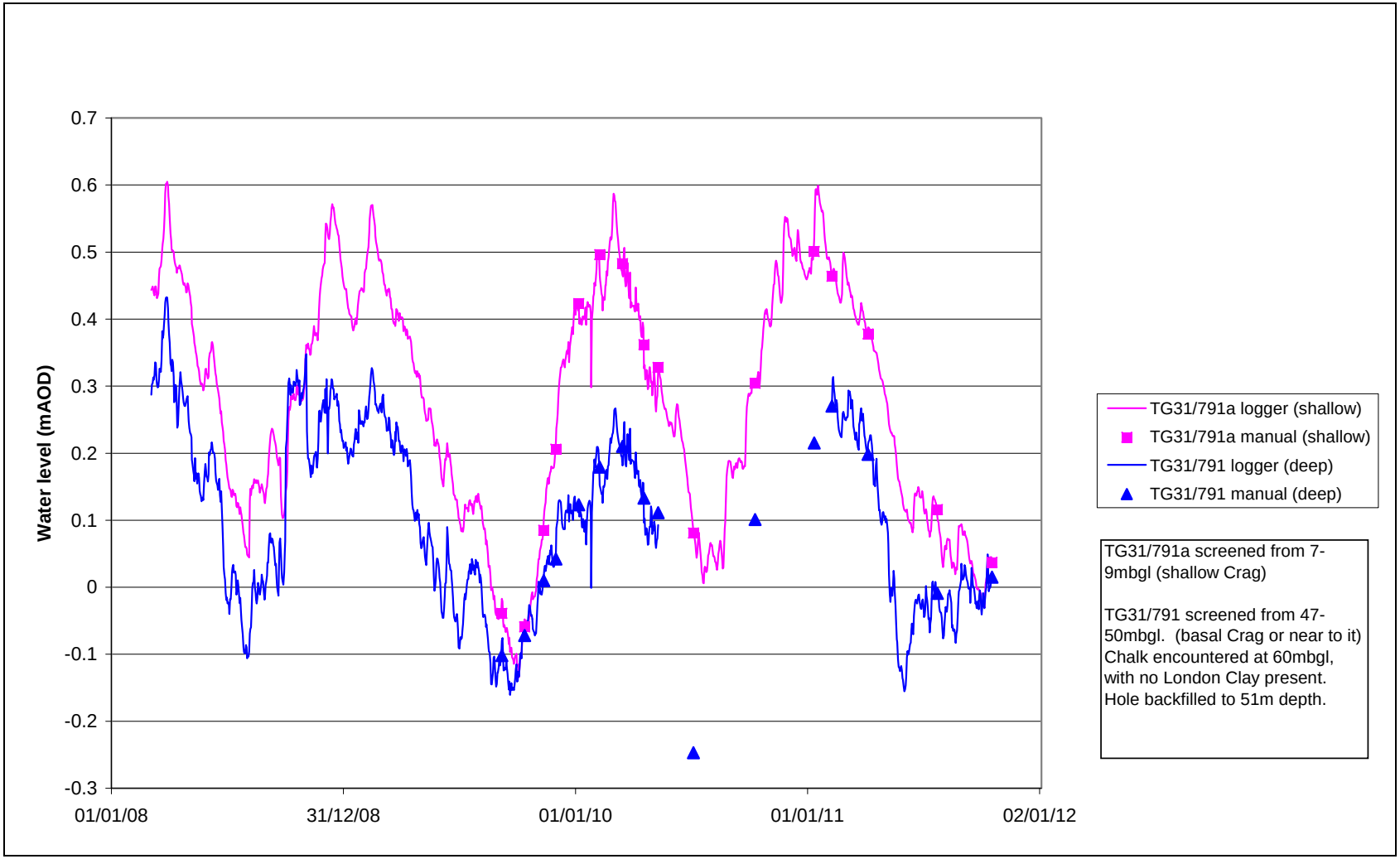


Figure E19 – Groundwater levels in two boreholes to the south of Catfield Fen, and to the west of the AWS Ludham PWS source

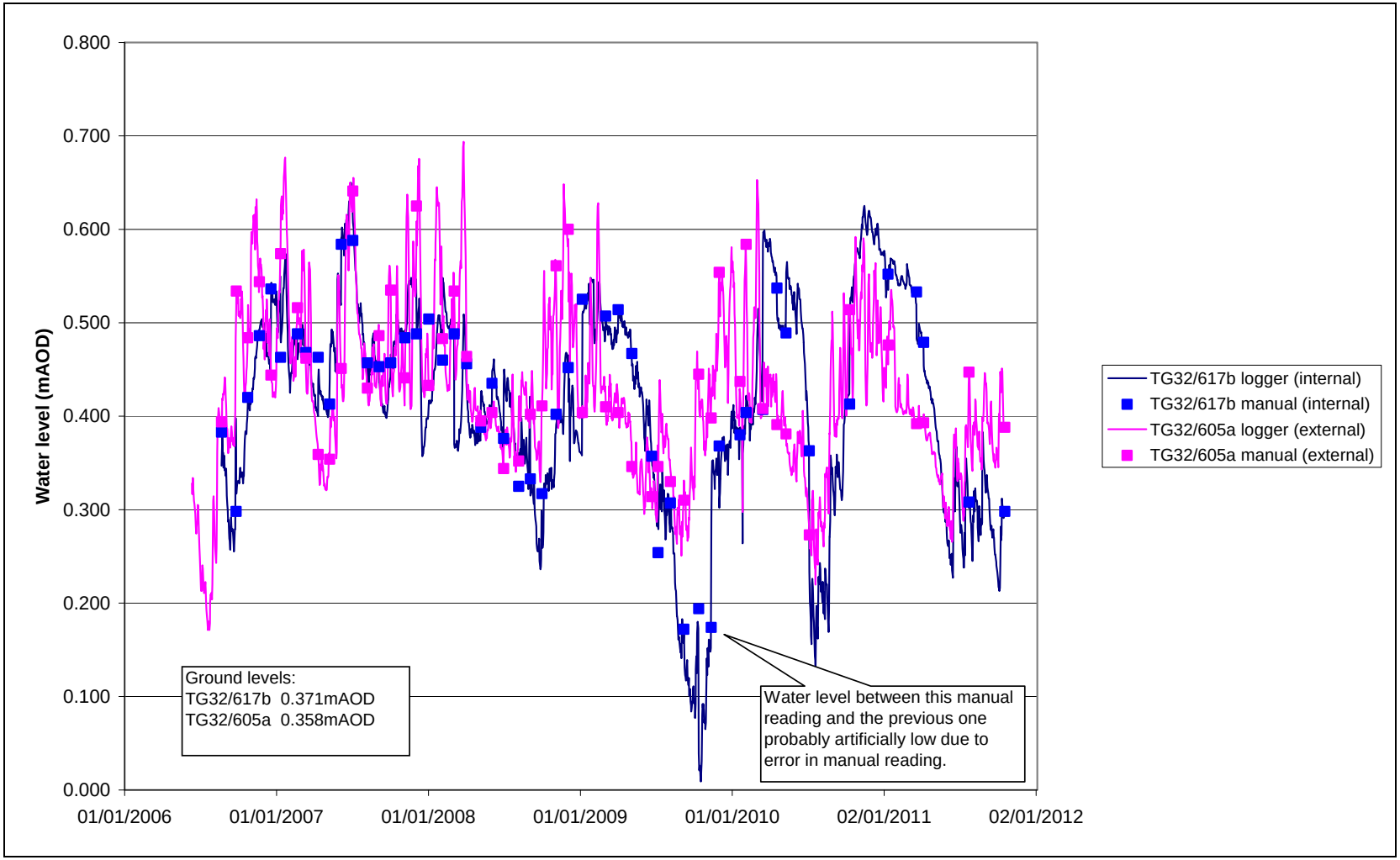


Figure E20 – Comparison of dipwell water levels in the internal and external systems

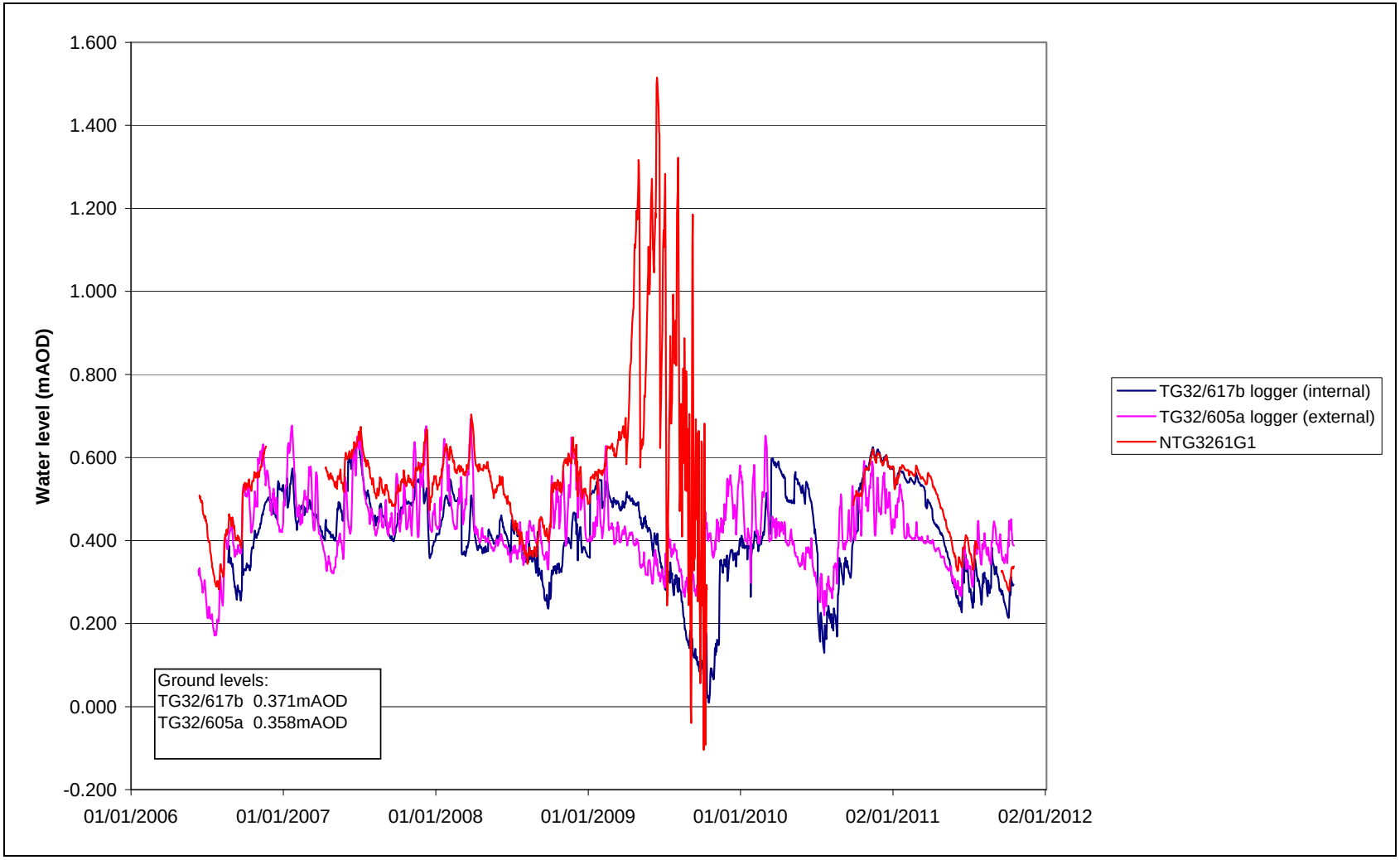


Figure E21 – Comparison of dipwell water levels with those at gaugeboard NTG3261G1 in the internal system

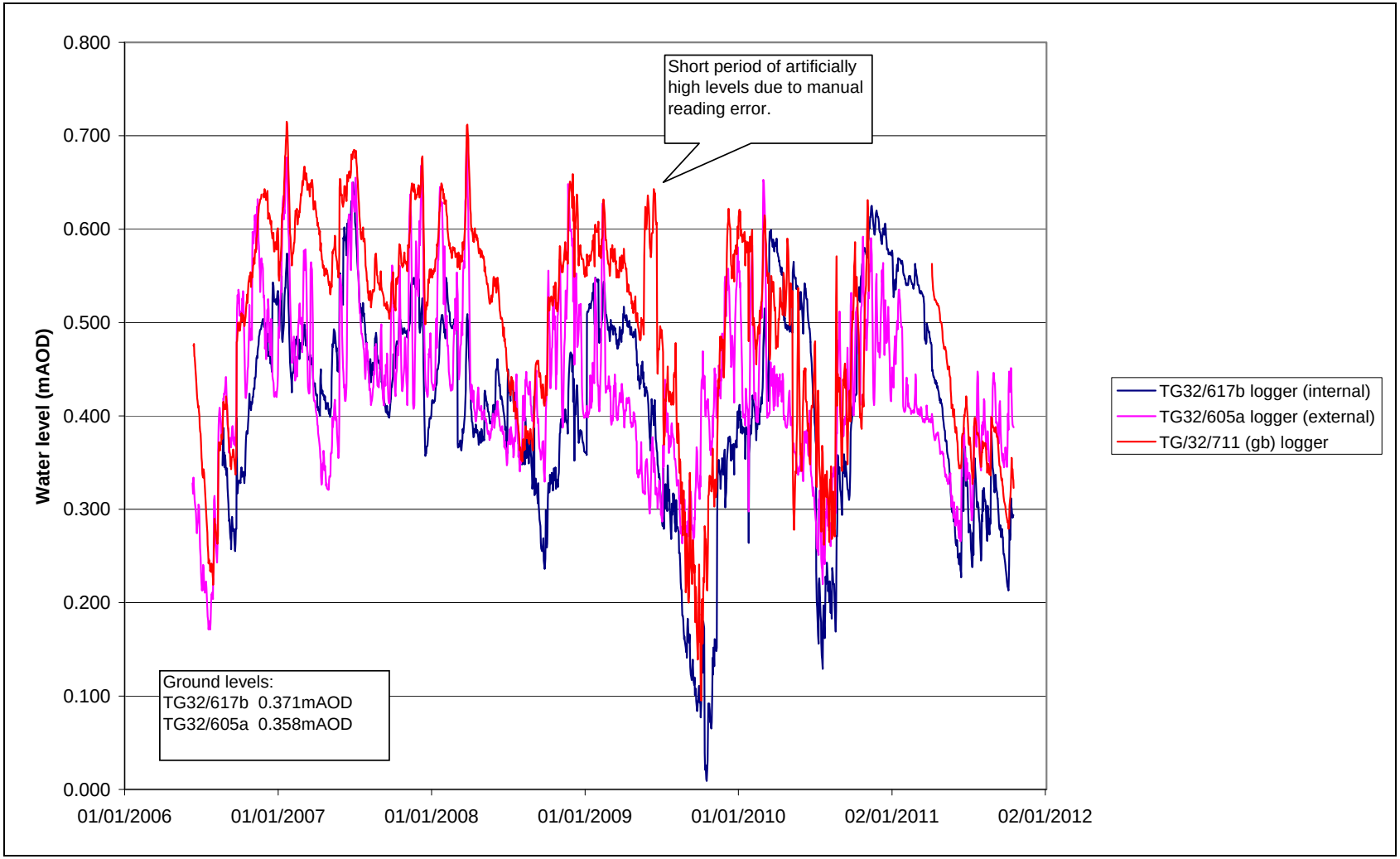


Figure E22 – Comparison of dipwell water levels with those at gaugeboard TG32/711 in the internal system

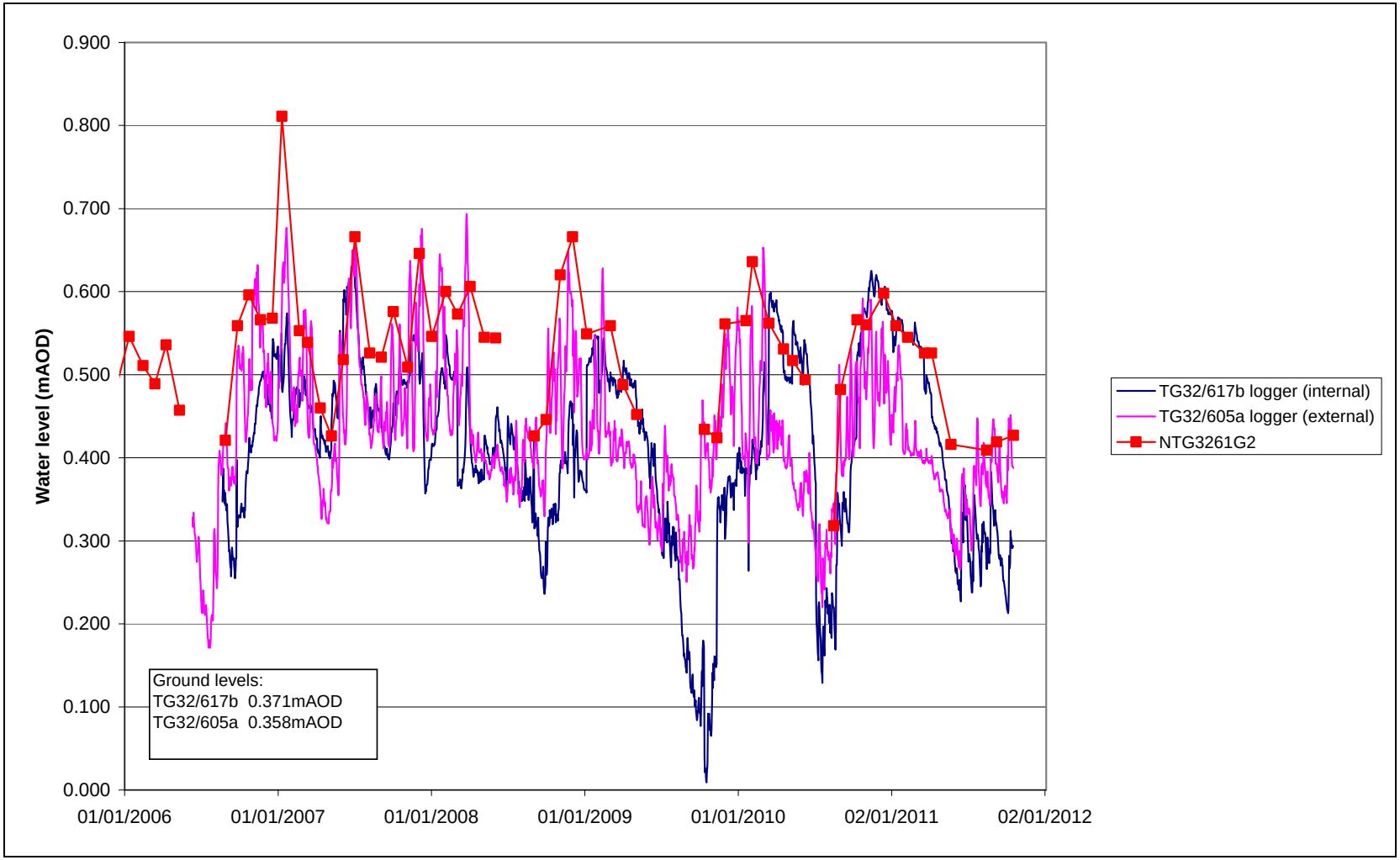


Figure E23 – Comparison of dipwell water levels with those at gaugeboard NTG3261G2 in the external system

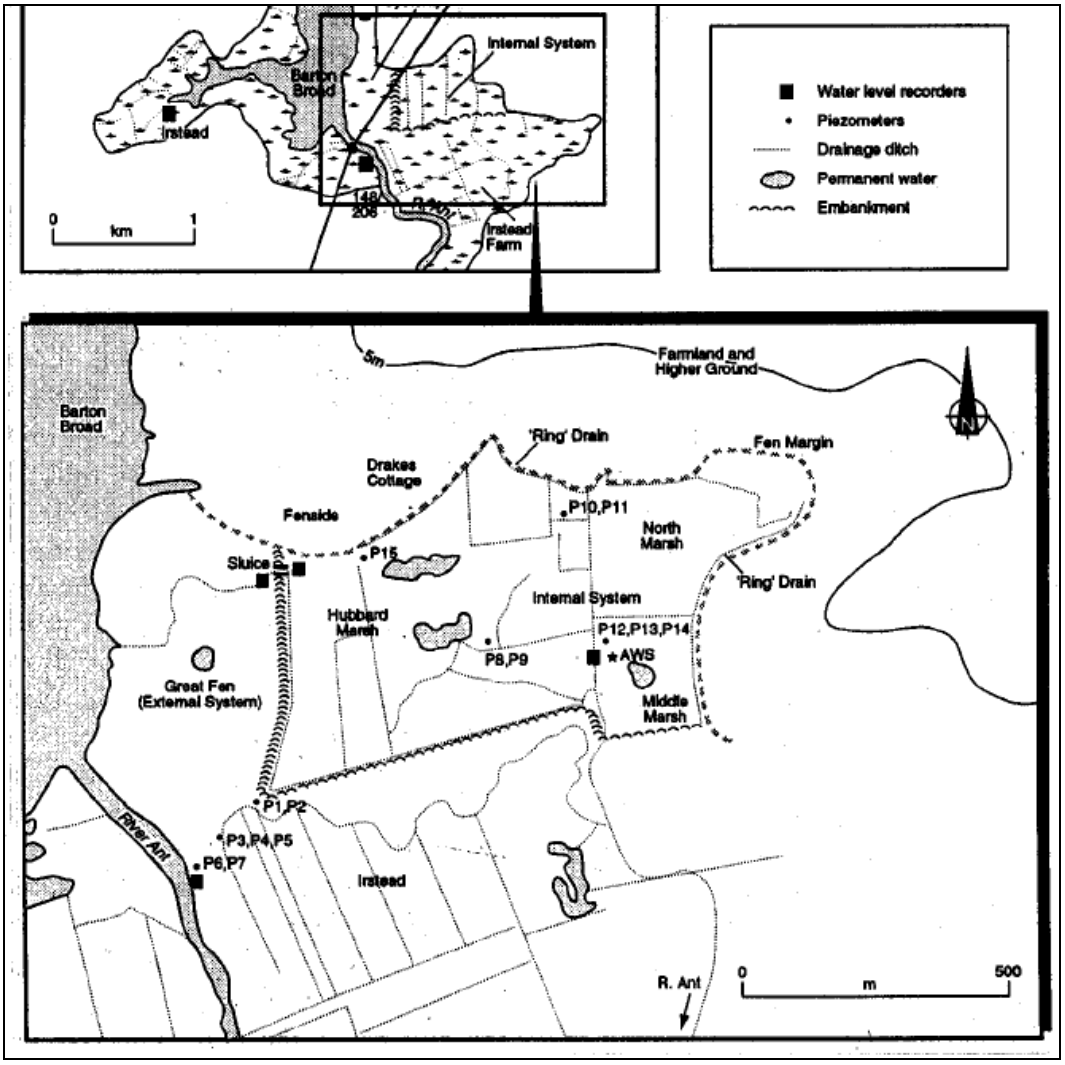


Figure E24 – Location of University of Birmingham monitoring (from Gilvear et al., 1997)

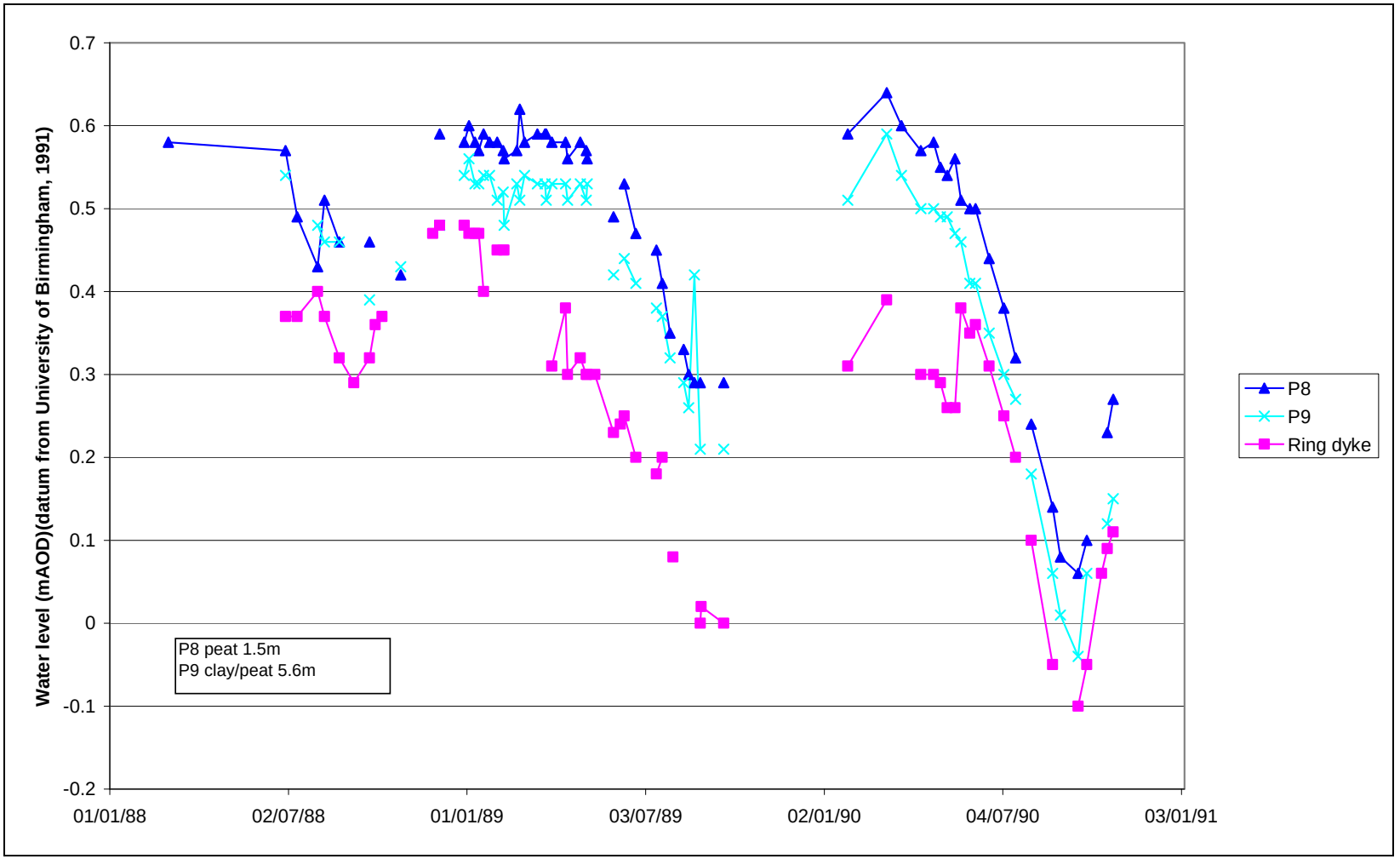


Figure E25 – Water levels from University of Birmingham piezometers P8 & P9 in the internal system and from the Ring Dyke at an unspecified location (Water levels from University of Birmingham, 1991; Piezometer lithology monitored and depth from Gilvear et al., 1997)

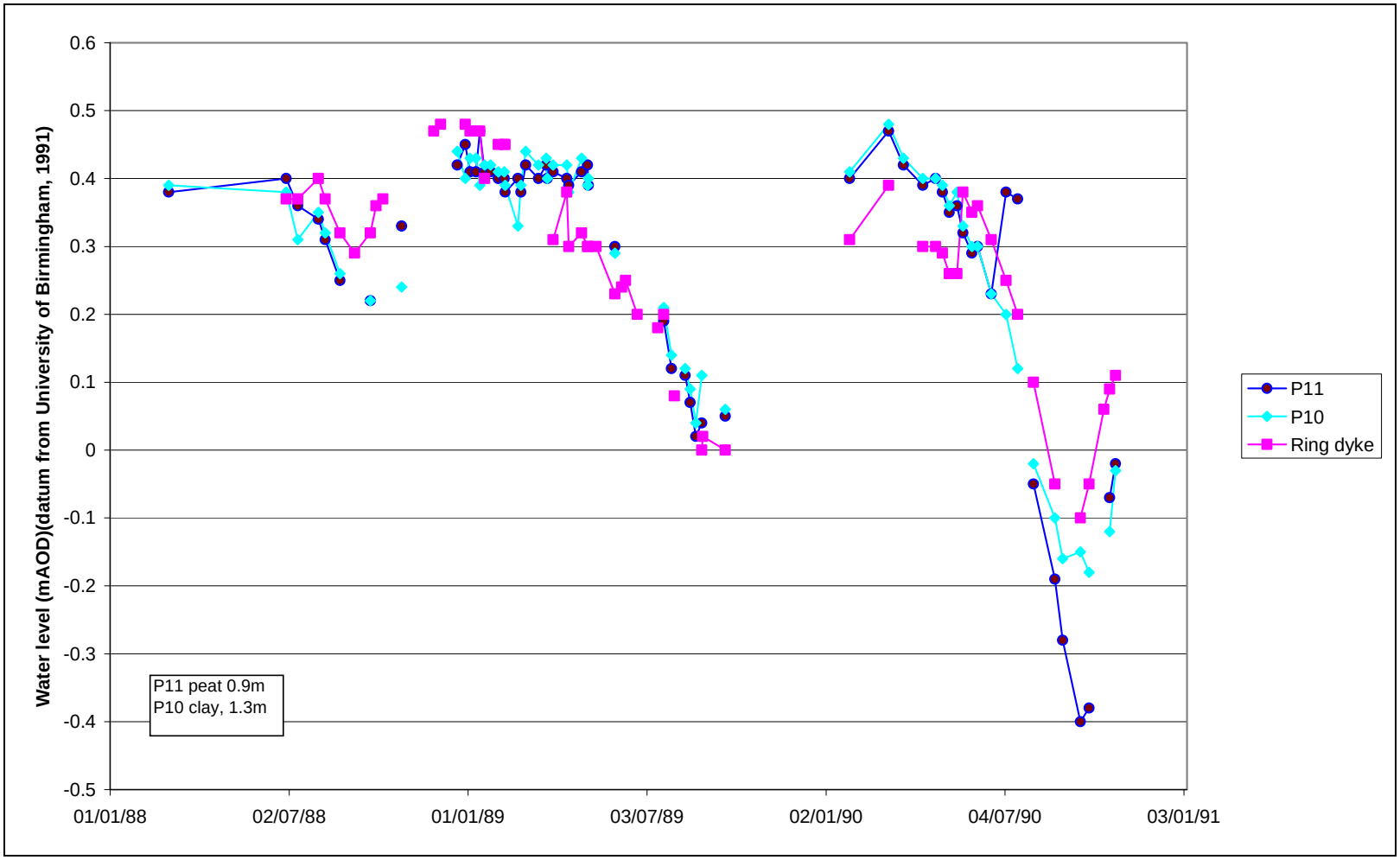


Figure E26 – Water levels from University of Birmingham piezometers P10 & P11 in the internal system and from the Ring Dyke at an unspecified location (Water levels from University of Birmingham, 1991; Piezometer lithology monitored and depth from Gilvear et al., 1997)

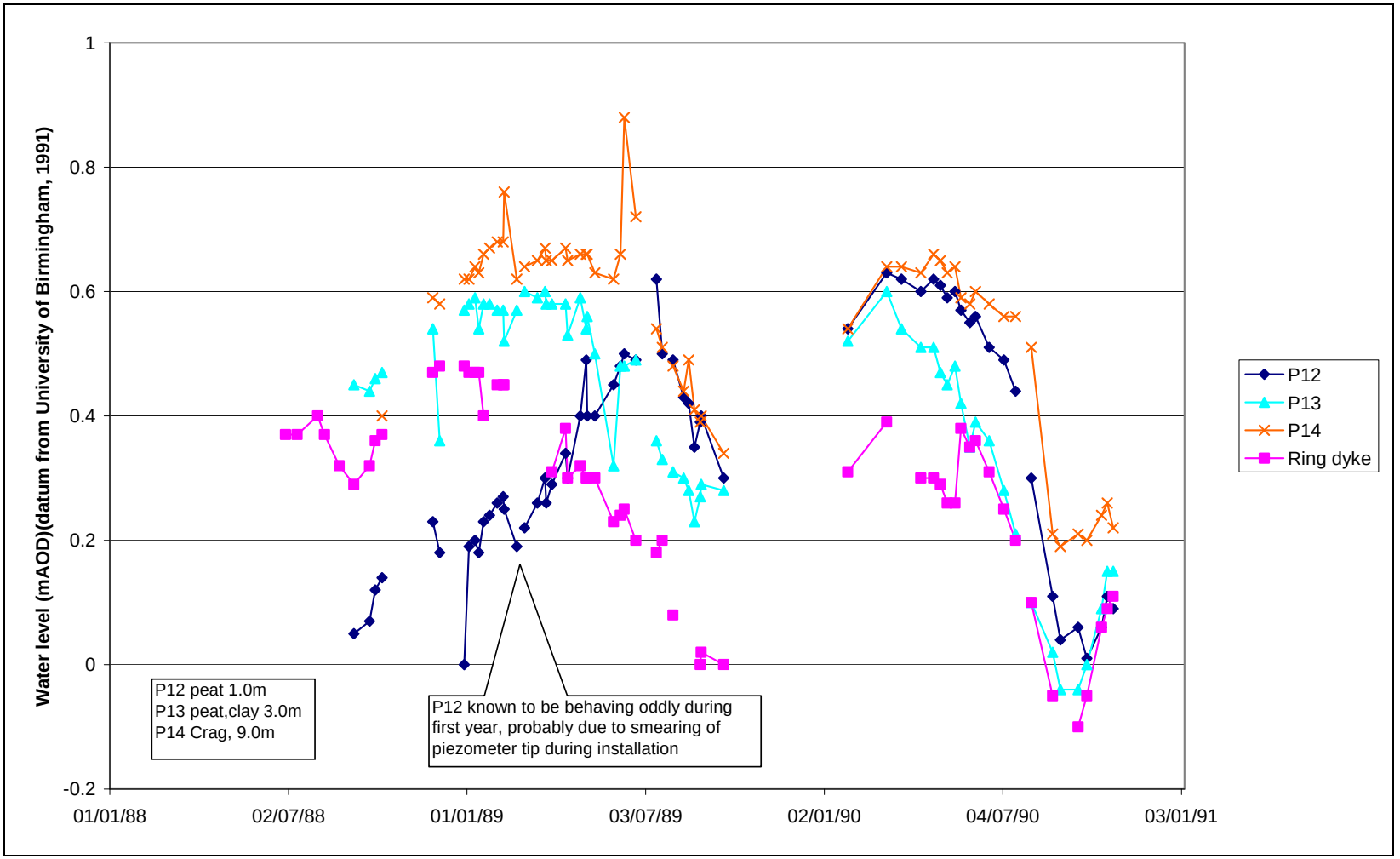


Figure E27 – Water levels from University of Birmingham piezometers P12, P13 & P14 in the internal system and from the Ring Dyke at an unspecified location (Water levels from University of Birmingham, 1991; Piezometer lithology monitored and depth from Gilvear et al., 1997)

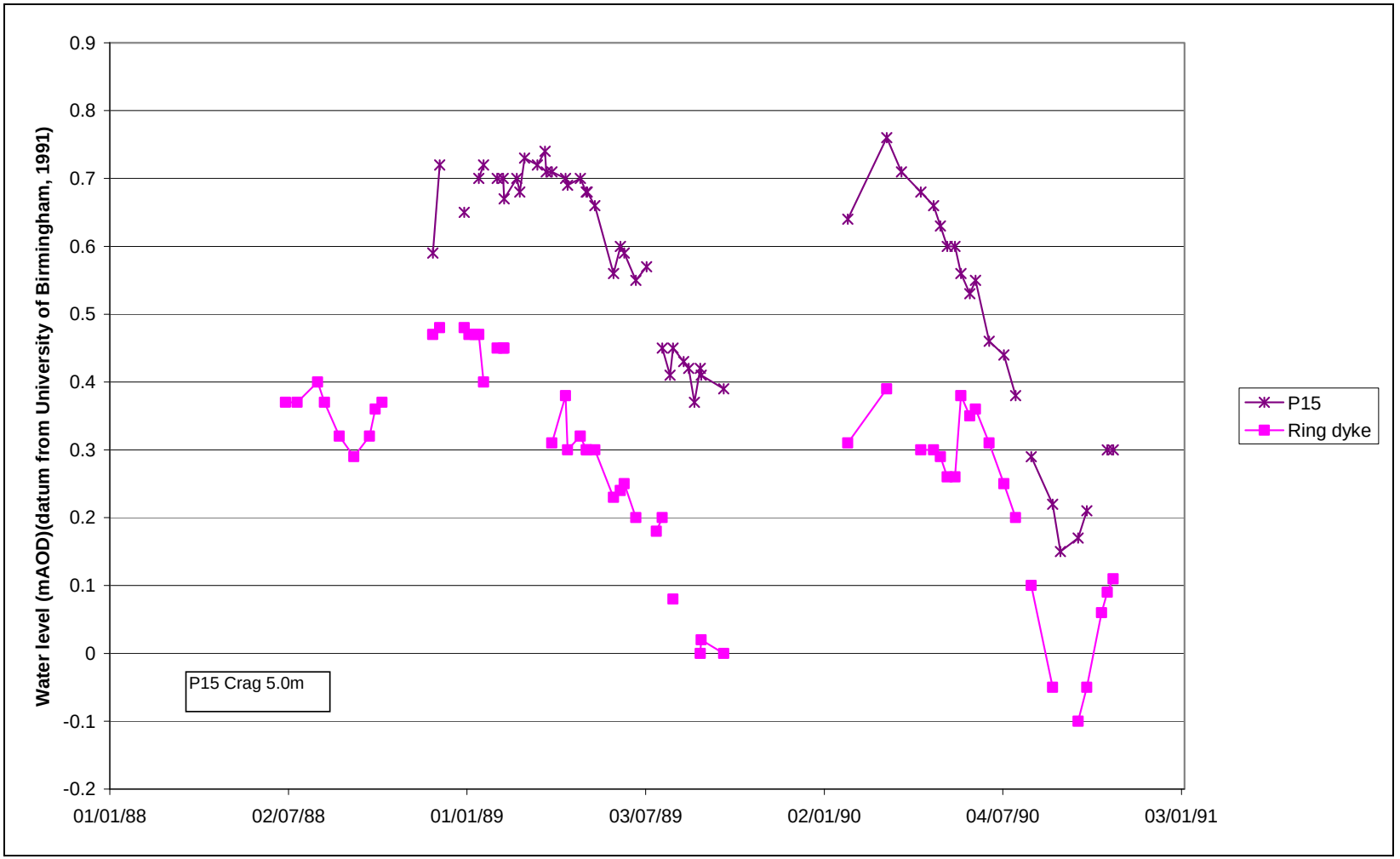


Figure E28 – Water levels from University of Birmingham piezometer P15 in the internal system and from the Ring Dyke at an unspecified location (Water levels from University of Birmingham, 1991; Piezometer lithology monitored and depth from Gilvear et al., 1997)

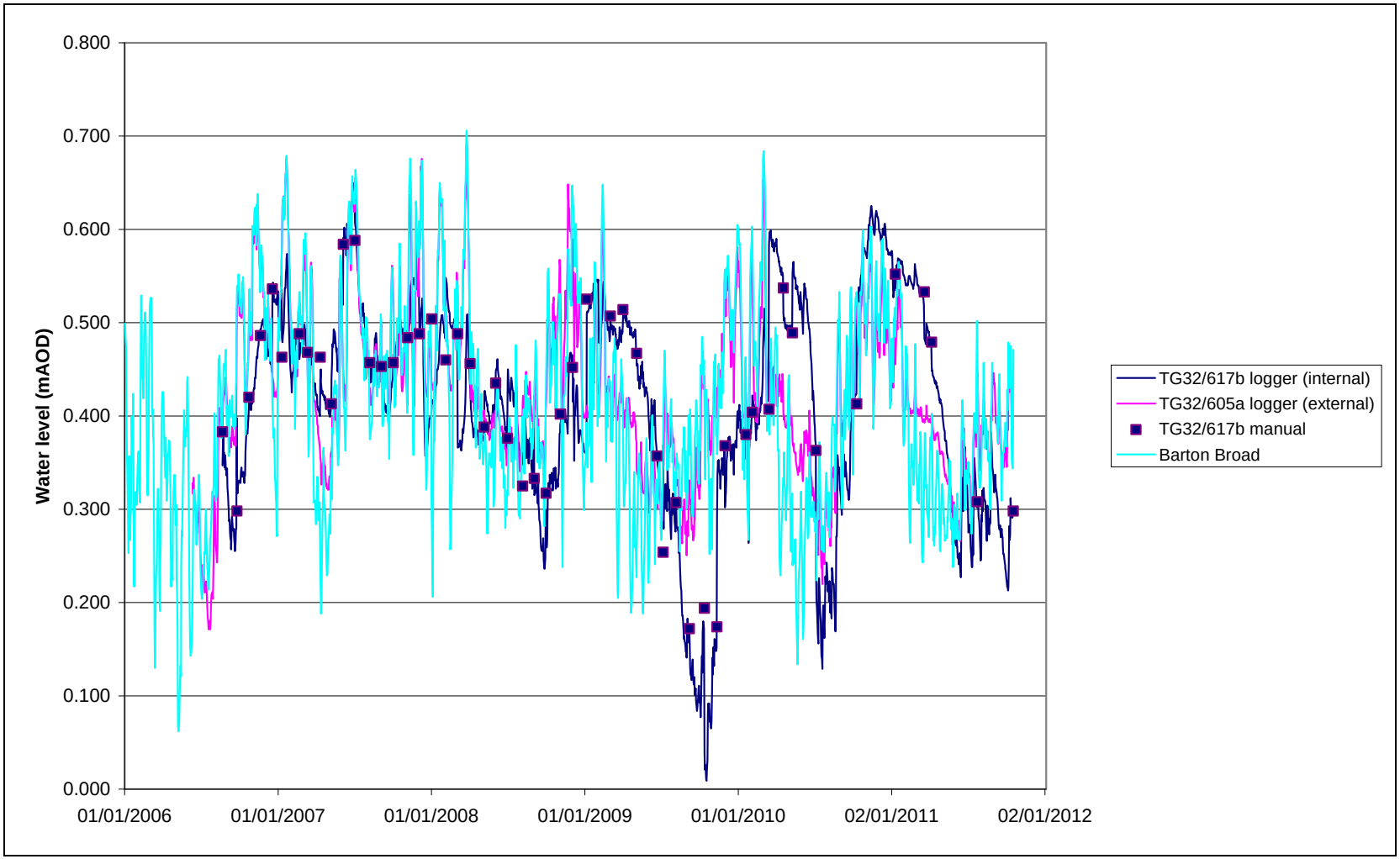


Figure E29 – Comparison of dipwell water levels with water levels at Barton Broad

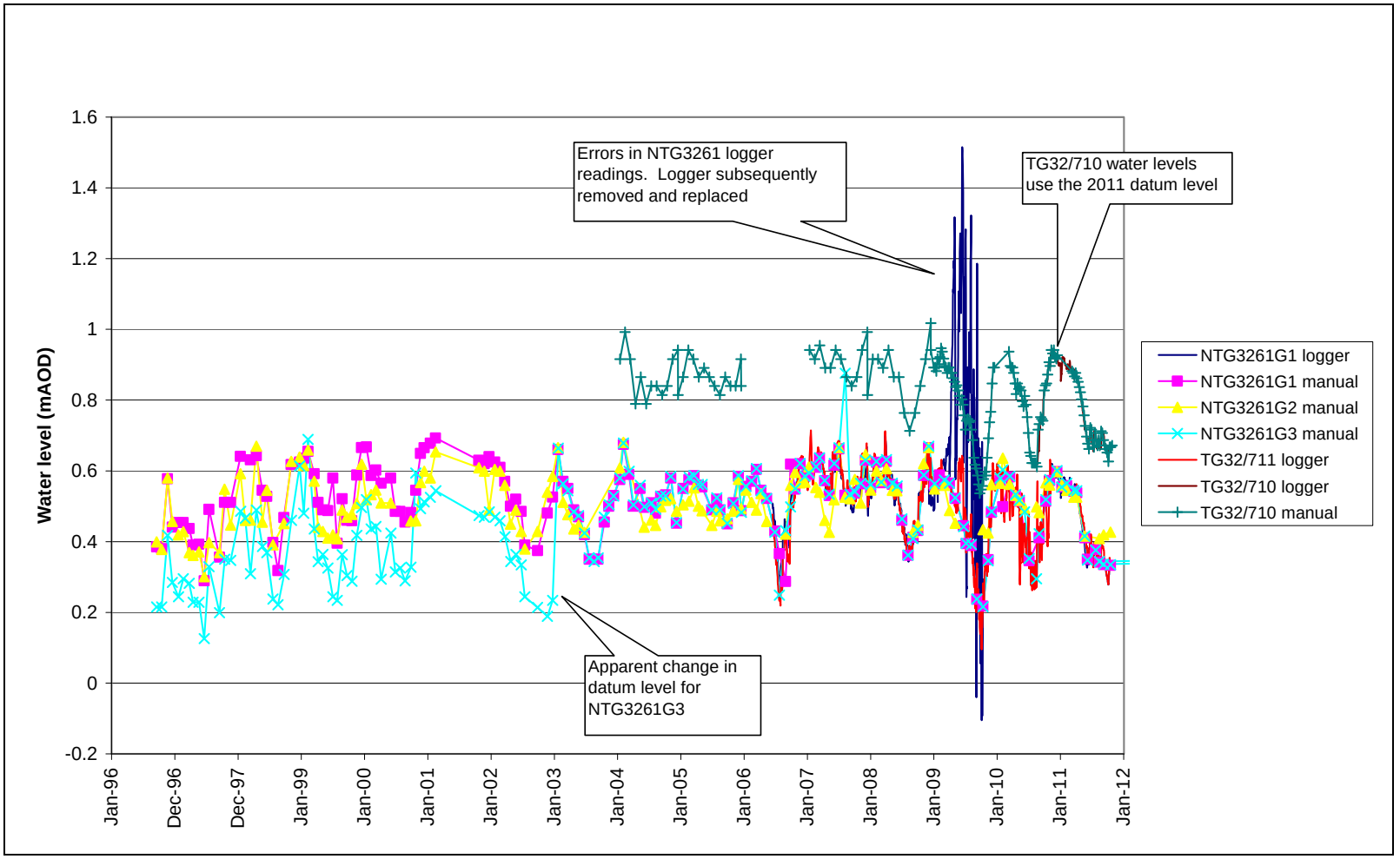


Figure E30 – Gaugeboard water levels 1996-2011 (All in the internal system except NTG3261G2 which is in the external system)

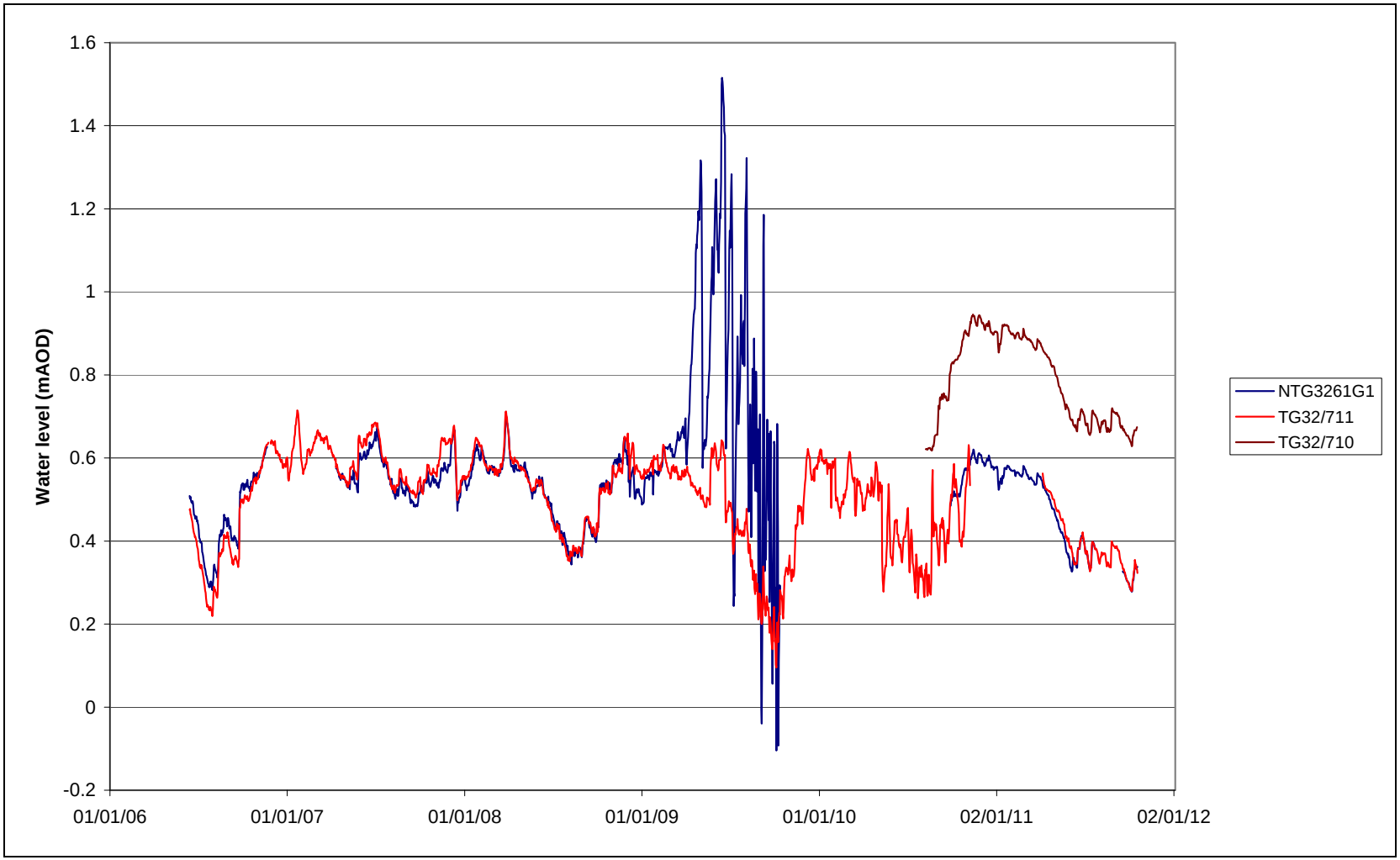


Figure E31 – Gaugeboard water levels – logger data (NTG3261G1 & TG32/711 in the west, TG32/710 in the east)

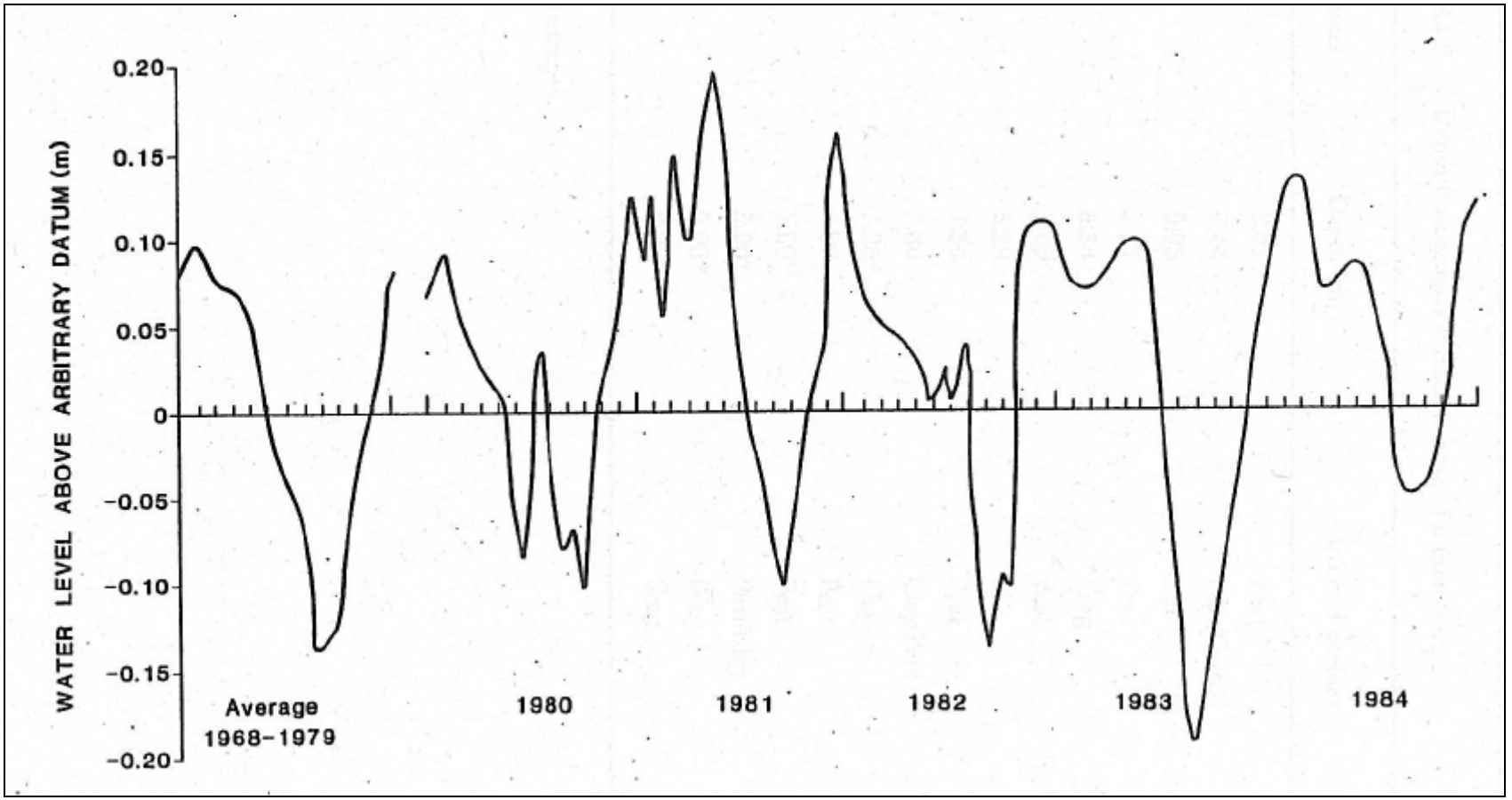


Figure E32 – Water levels monitored at a post by Dr S MacDougall (from University of Birmingham, 1991)

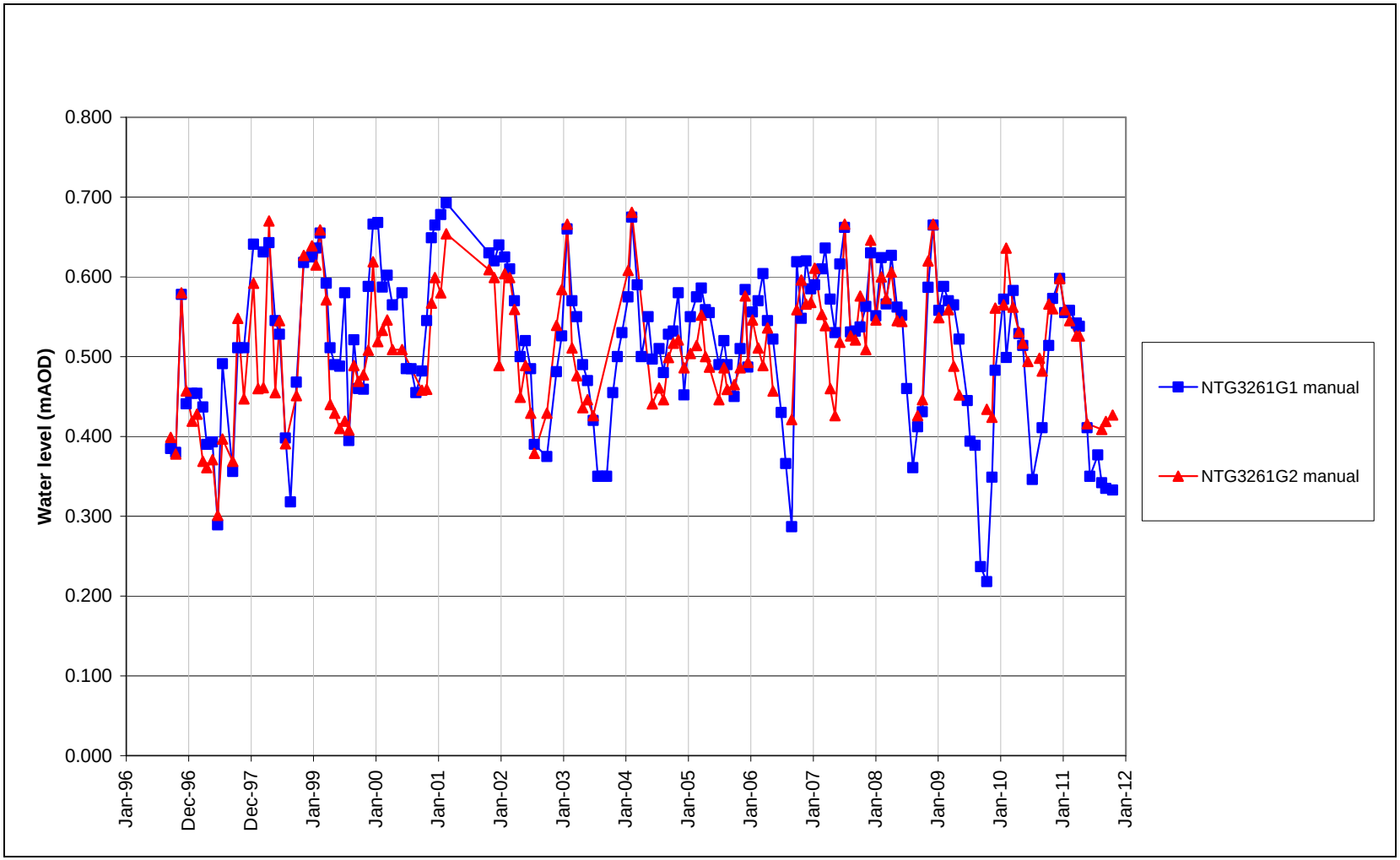


Figure E33 – A comparison of internal and external system water levels using manual data (NTG3261G1 internal; NTG3261G2 external)

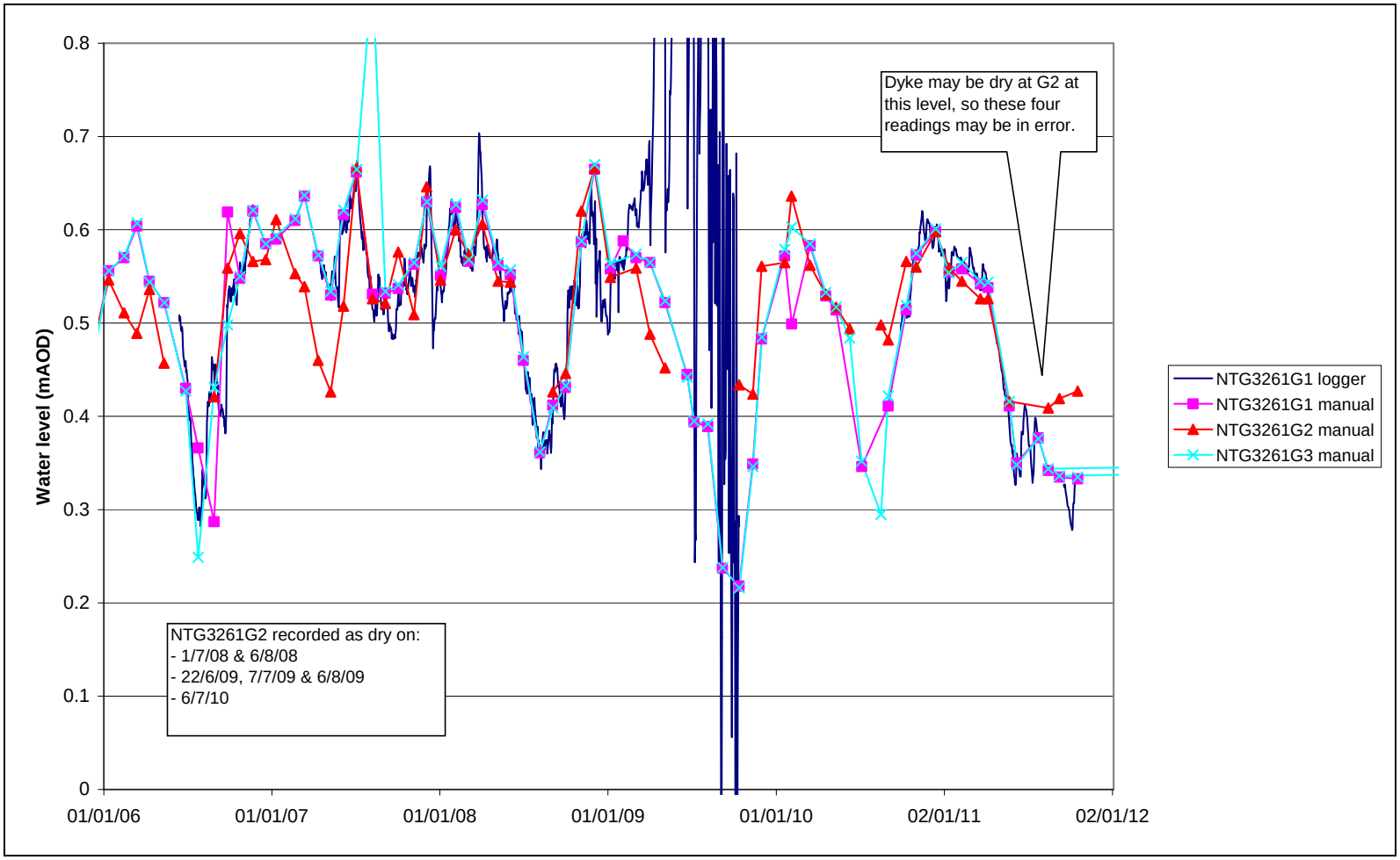


Figure E34 – A comparison of water levels in the internal and external systems, 2006-2011 (NTG3261G1 & G3 internal; NTG3261G2 external)

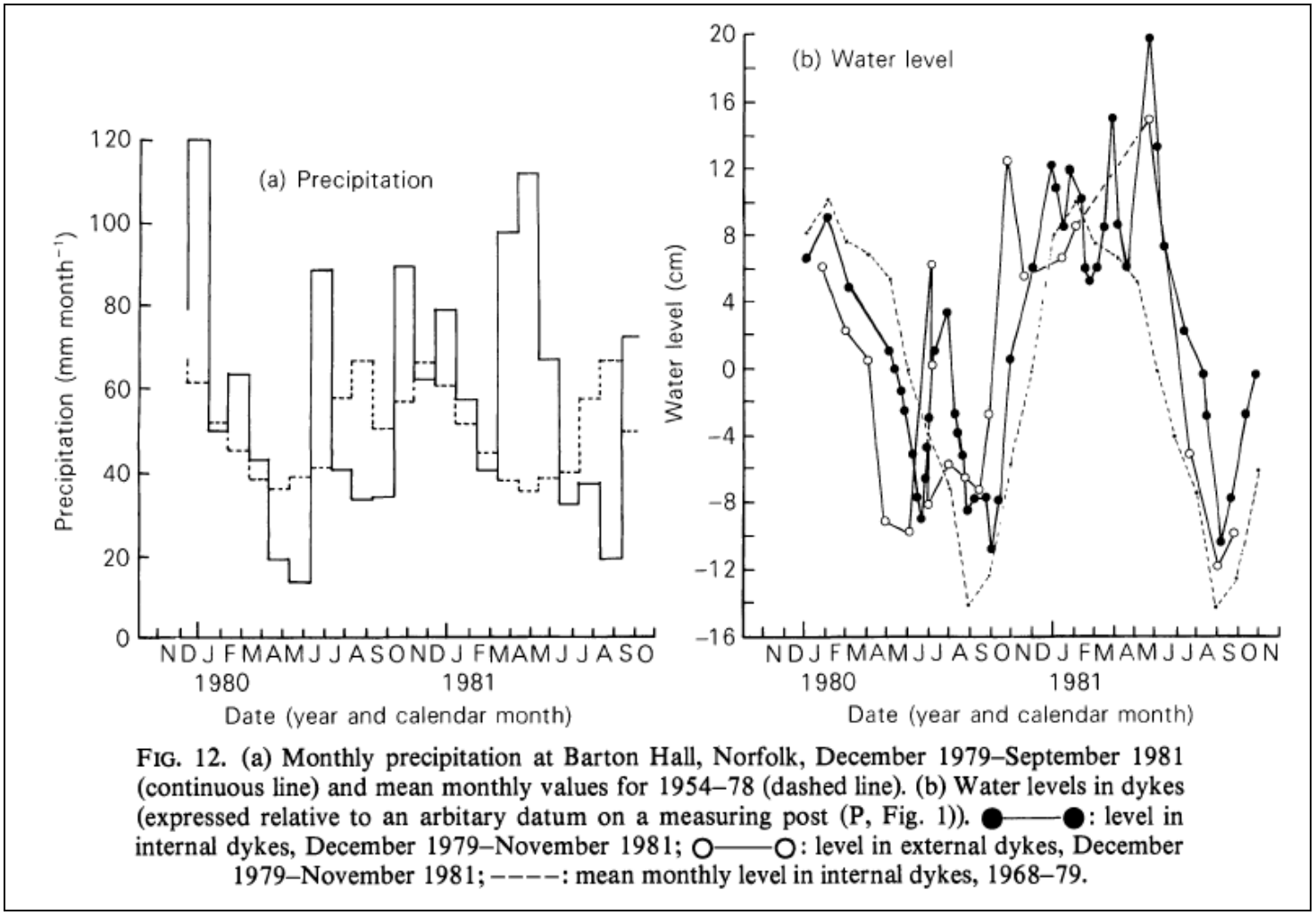


FIG. 12. (a) Monthly precipitation at Barton Hall, Norfolk, December 1979–September 1981 (continuous line) and mean monthly values for 1954–78 (dashed line). (b) Water levels in dykes (expressed relative to an arbitary datum on a measuring post (P, Fig. 1)). ●——●: level in internal dykes, December 1979–November 1981; O——O: level in external dykes, December 1979–November 1981; – – – –: mean monthly level in internal dykes, 1968–79.

Figure E35 – Water levels within the internal and external systems December 1979 to November 1981 (from Giller & Wheeler, 1986a, Figure 12)

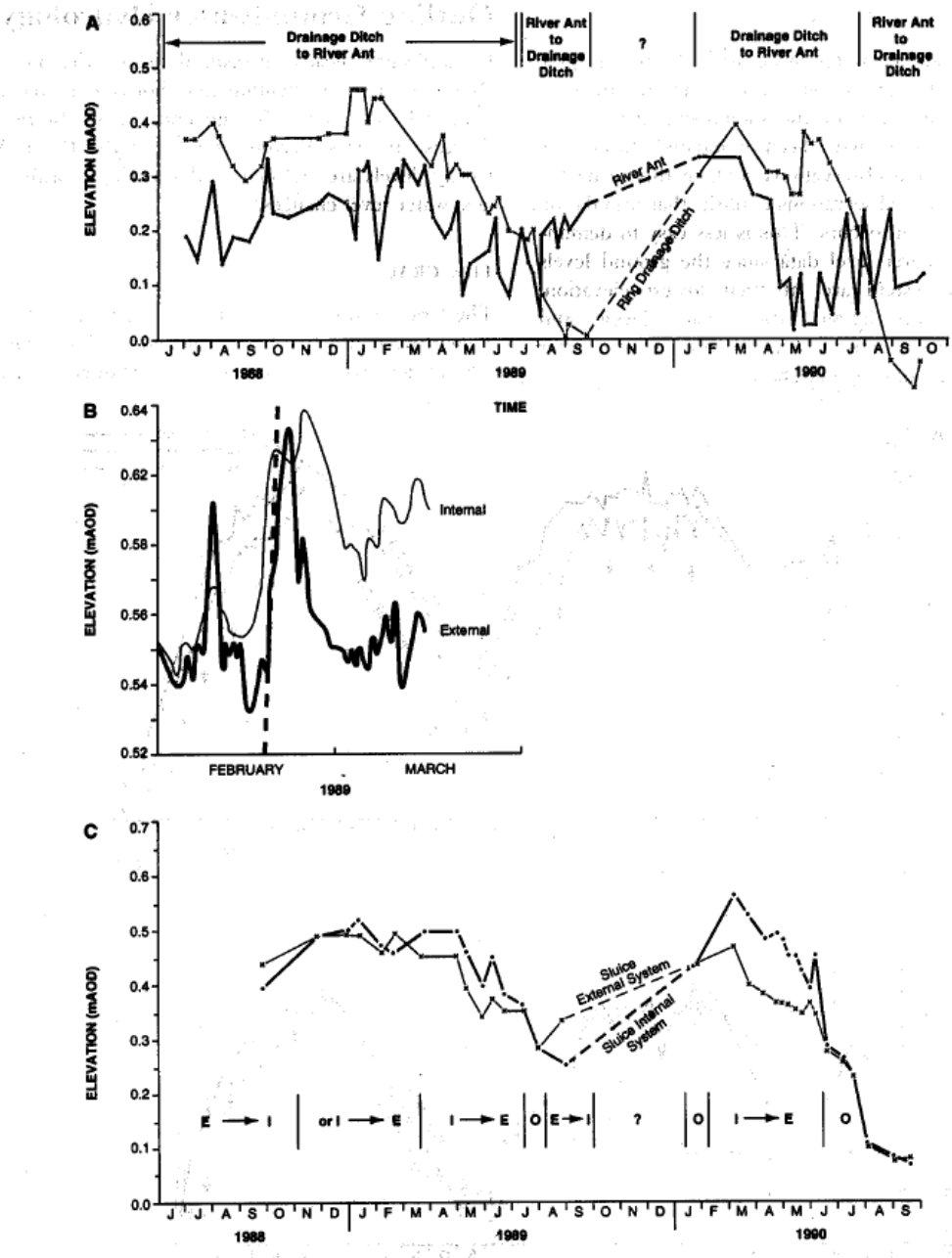


Fig. 4 *Comparison of Catfield Fen 'internal' and external water level fluctuations during the monitoring period (A) Barton Broad water level variations based on weekly data and internal drainage ditch water levels. Periods of potential inflow and outflow are shown. (B) Hourly data for February and March 1989 either side of the sluice indicating periods of inflow and outflow from the internal system (C) Weekly water levels either side of the sluice indicating periods of inflow and outflow from the internal system. I to E designates time when flow is from the internal to external, zero no flow and E to I external to internal flow.*

Figure E36 – Dyke water levels in 1988-1990 (from Gilvear et al. 1997)

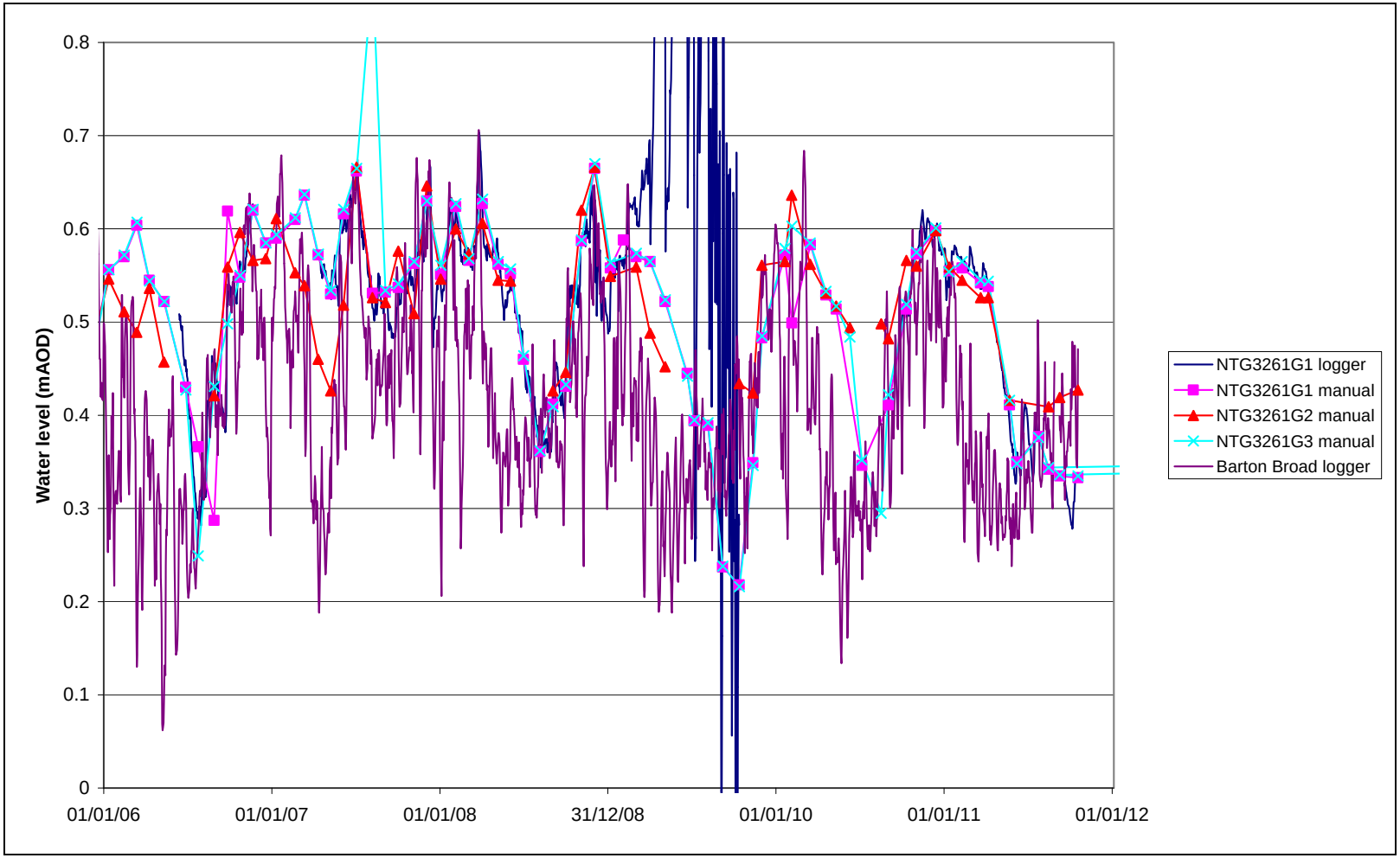


Figure E37 – A comparison of internal and external system water levels with those of Barton Broad

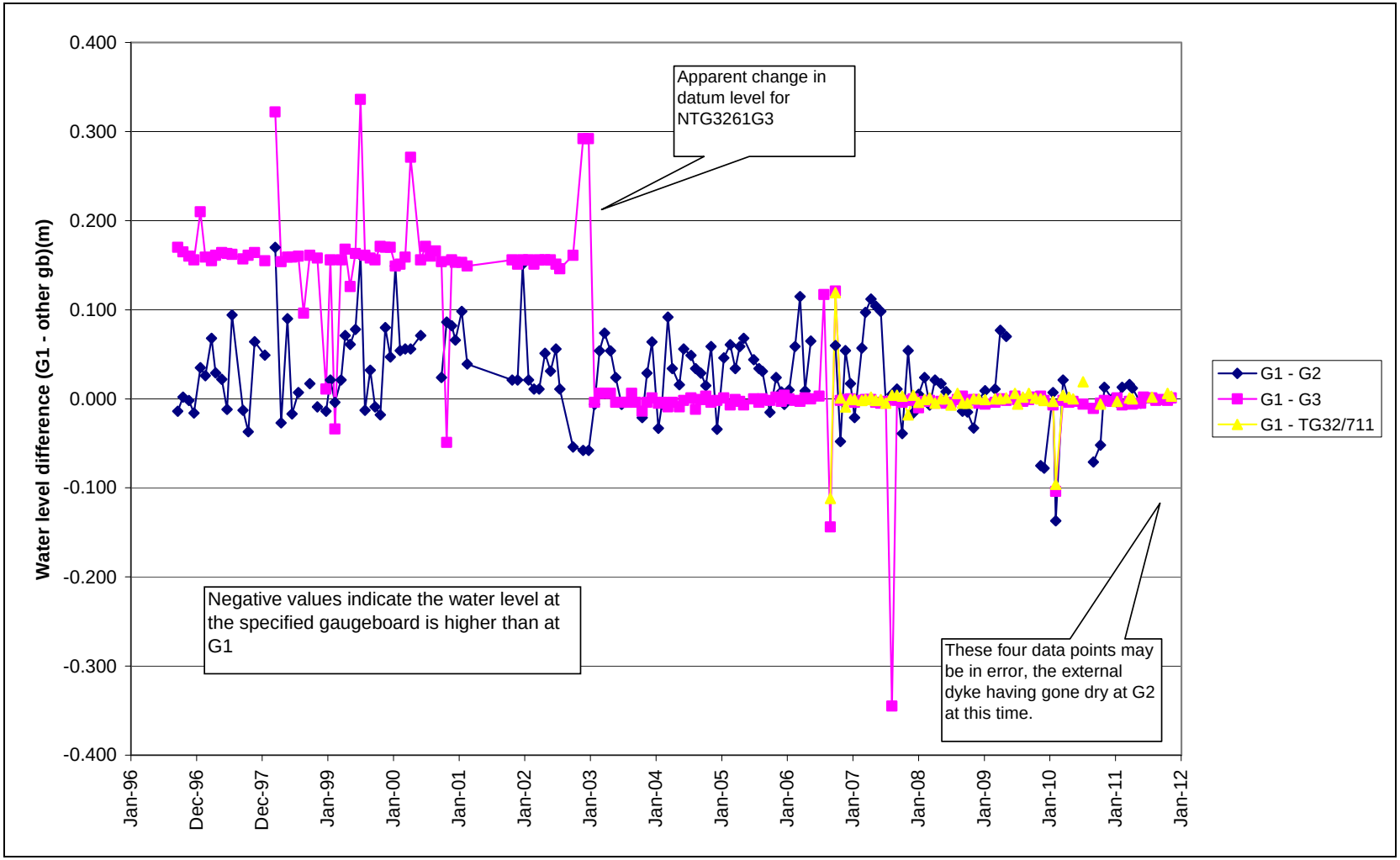


Figure E38 – Differences in water level between NTG3261G1 and those at other gaugeboards

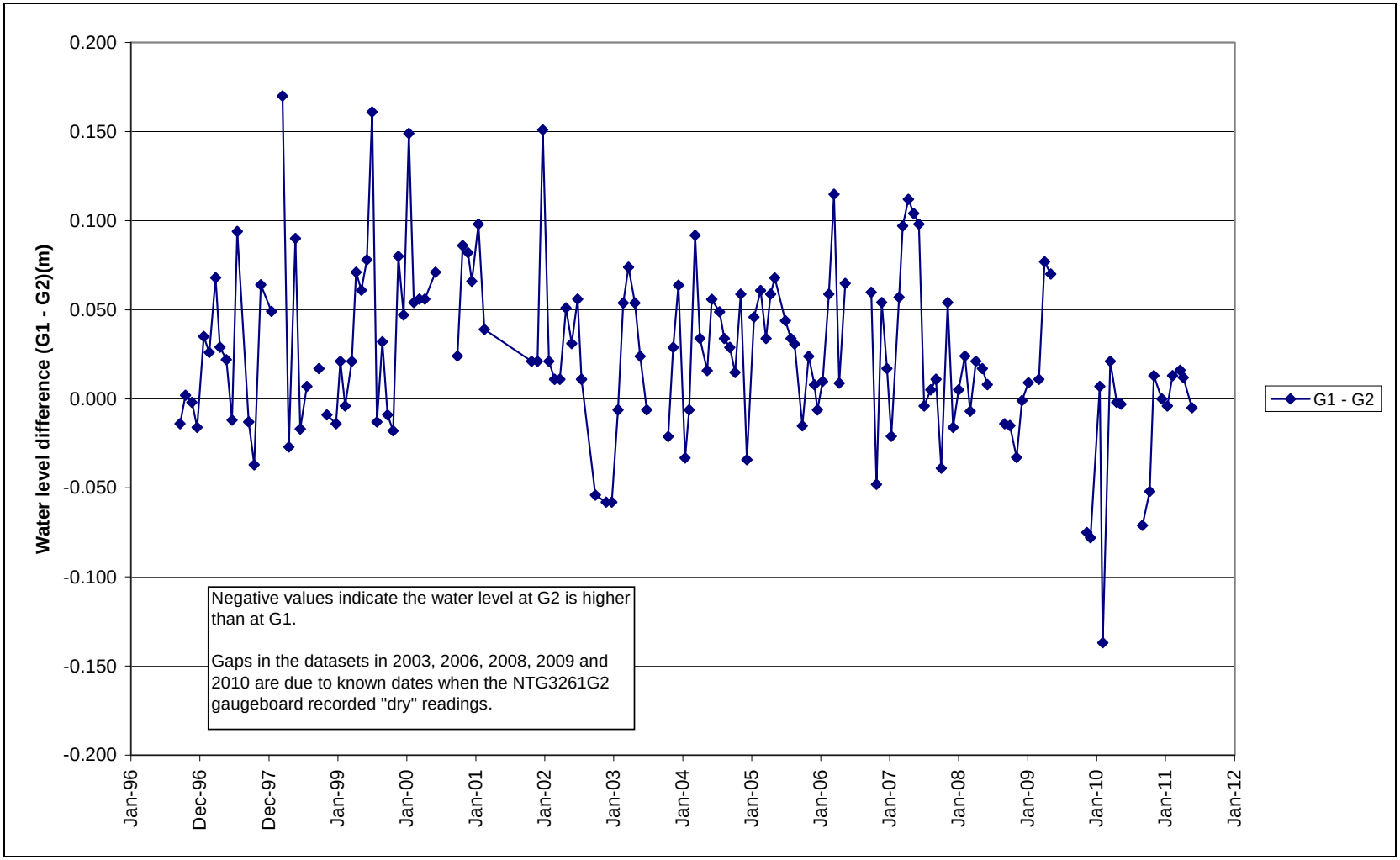
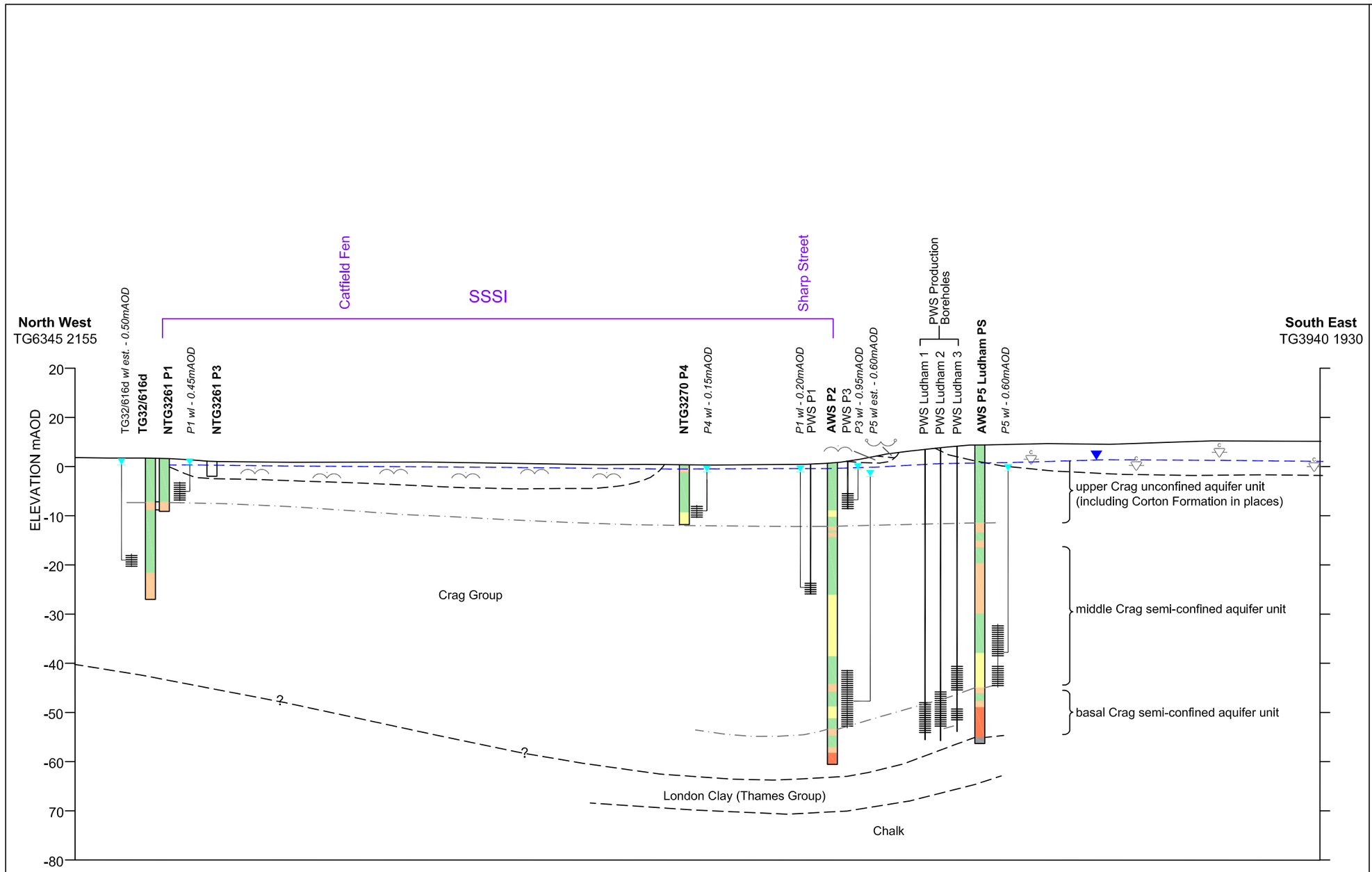


Figure E39 – Differences in water levels between NTG3261G1 (internal system) and NTG3261G2 (external system)



Key

- Undivided: mainly silt and clay (Breydon Formation [Bryd])
- Peat (Breydon Formation [Bryd])
- Corton Formation
- Crag
  - Sand
  - Silty sand
  - Sandy silt and clay
  - Shells in Clay matrix?
- London Clay (Thames Group)
- Geological boundary
- Crag unit boundary
- Crag piezometry
- Groundwater head, August 2002
- Borehole screened section

Notes

Clay at base of the peat is not shown.

Approximate x-y locations are given for those boreholes for which geology logs are not shown

wl = water level

est = estimated

0 m 500 m

Scale 1:12,500 @ A3

Environment Agency Anglian Region
Catfield Fen Investigation

Figure E40
Hydrogeological Section through Catfield Fen and AWS Ludham Showing Borehole Screeened Depths and Related Water Levels

March 2012
30321-S08.dwg parkj

amec

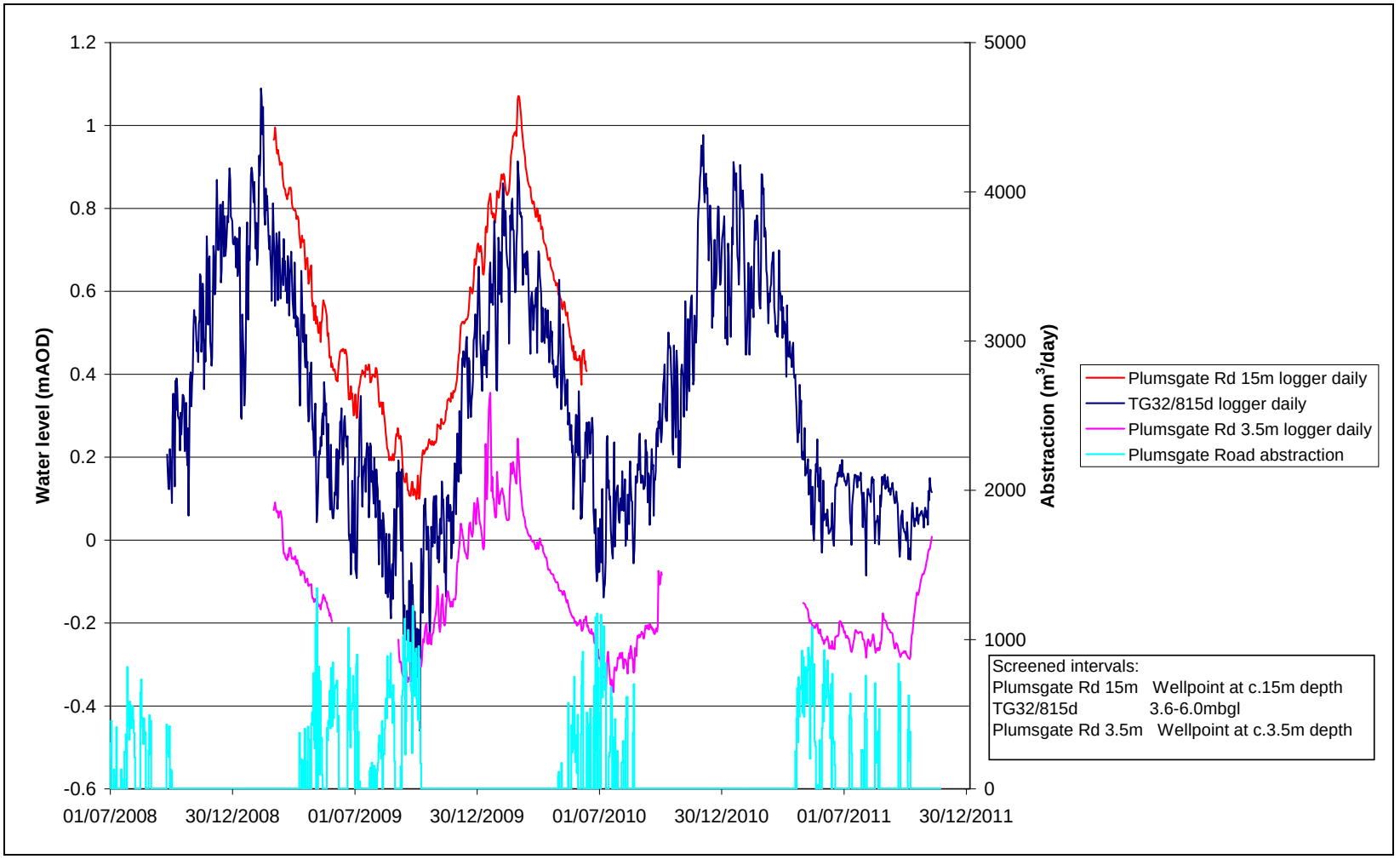


Figure E41 – Daily abstraction from the Plumsgate Road borehole with daily water level data from nearby boreholes
(Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

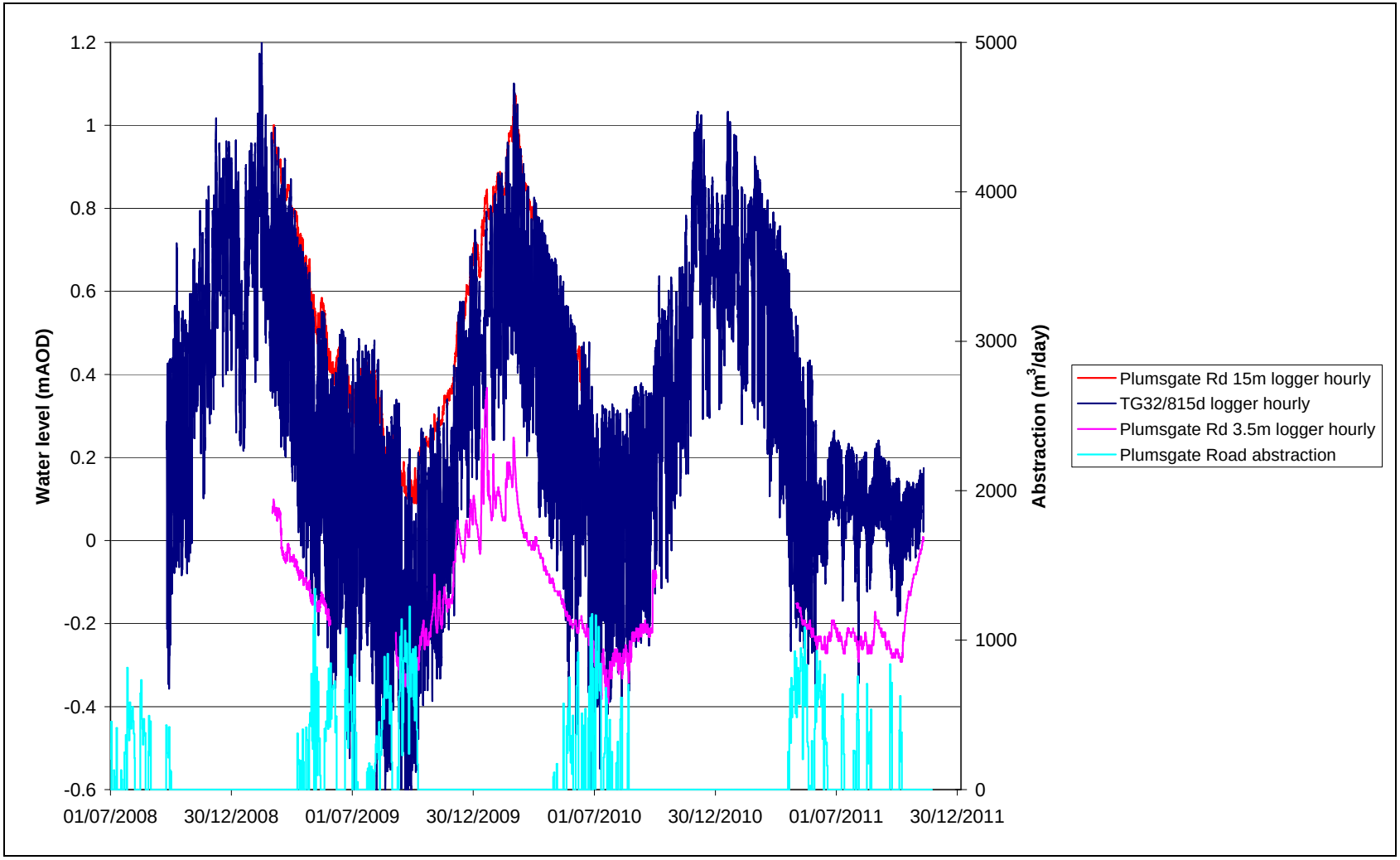


Figure E42 – Daily abstraction from the Plumsgate Road borehole with hourly water level data from nearby boreholes

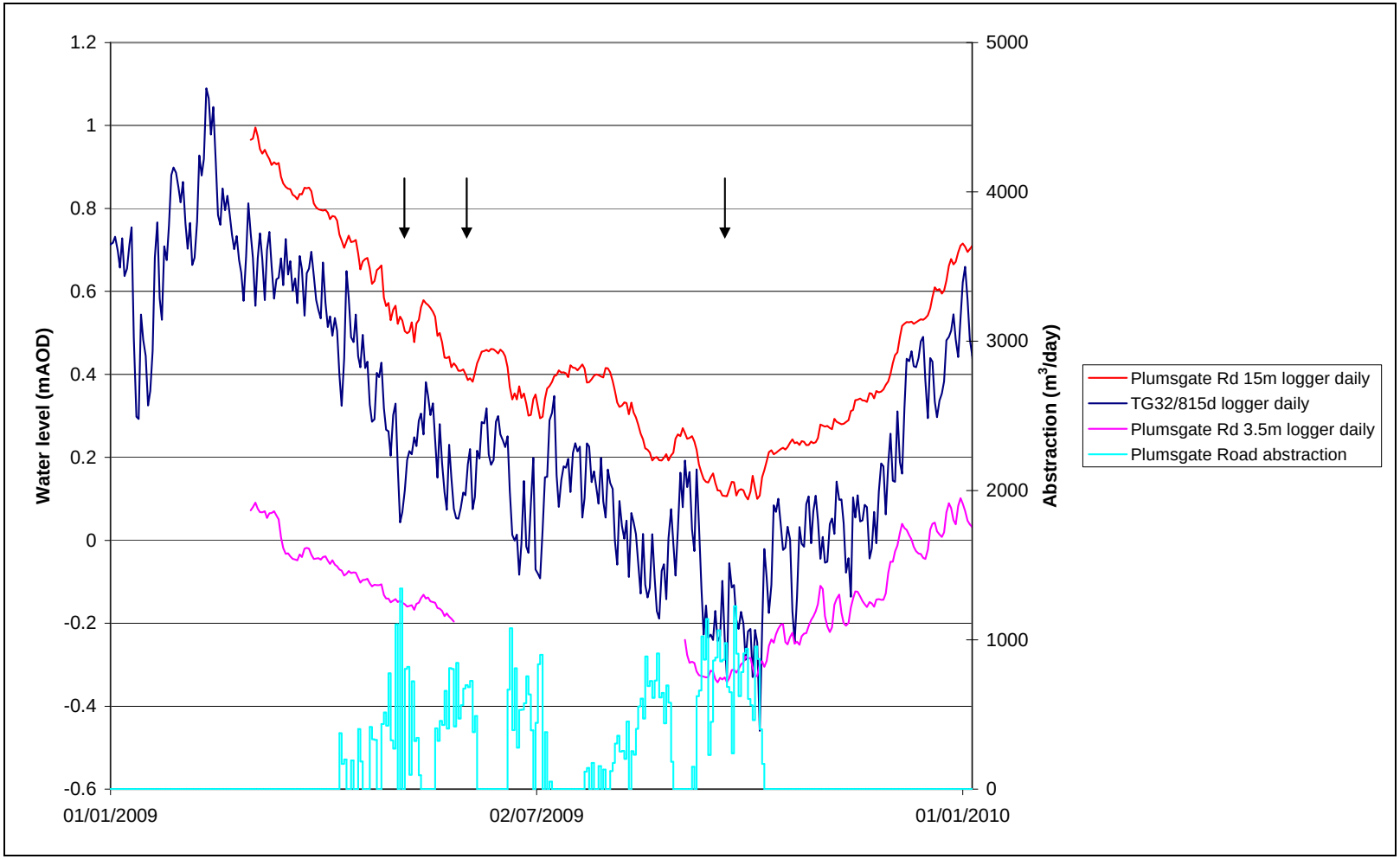


Figure E43 – Daily abstraction from the Plumsgate Road borehole in 2009 with water level data from nearby boreholes
(Arrows indicate abstraction periods referred to in Table 7.1. Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

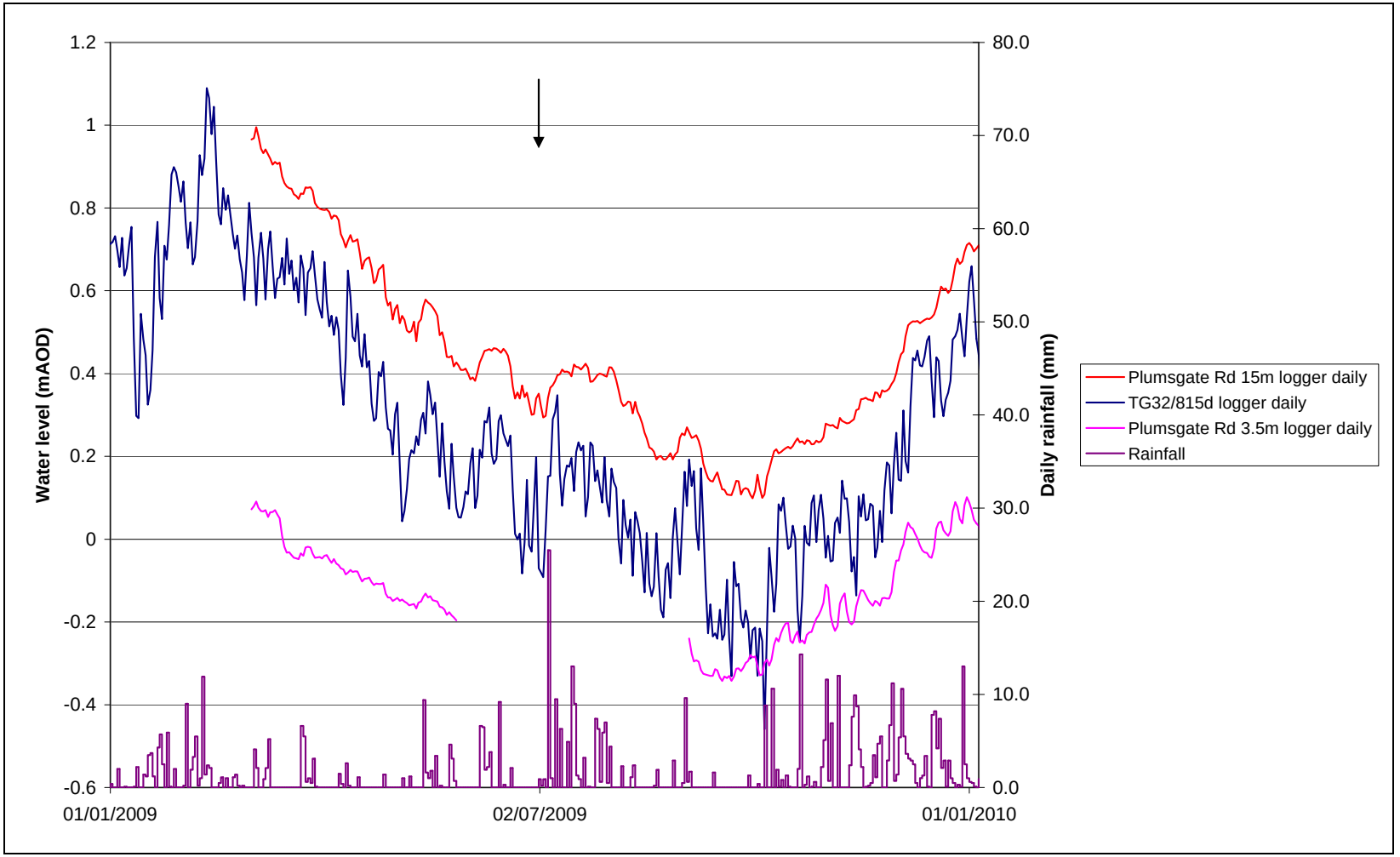


Figure E44 – Daily rainfall in 2009 with water level data from boreholes in the vicinity of the Plumsgate Road abstraction (Arrow refers to one of several rainfall events)

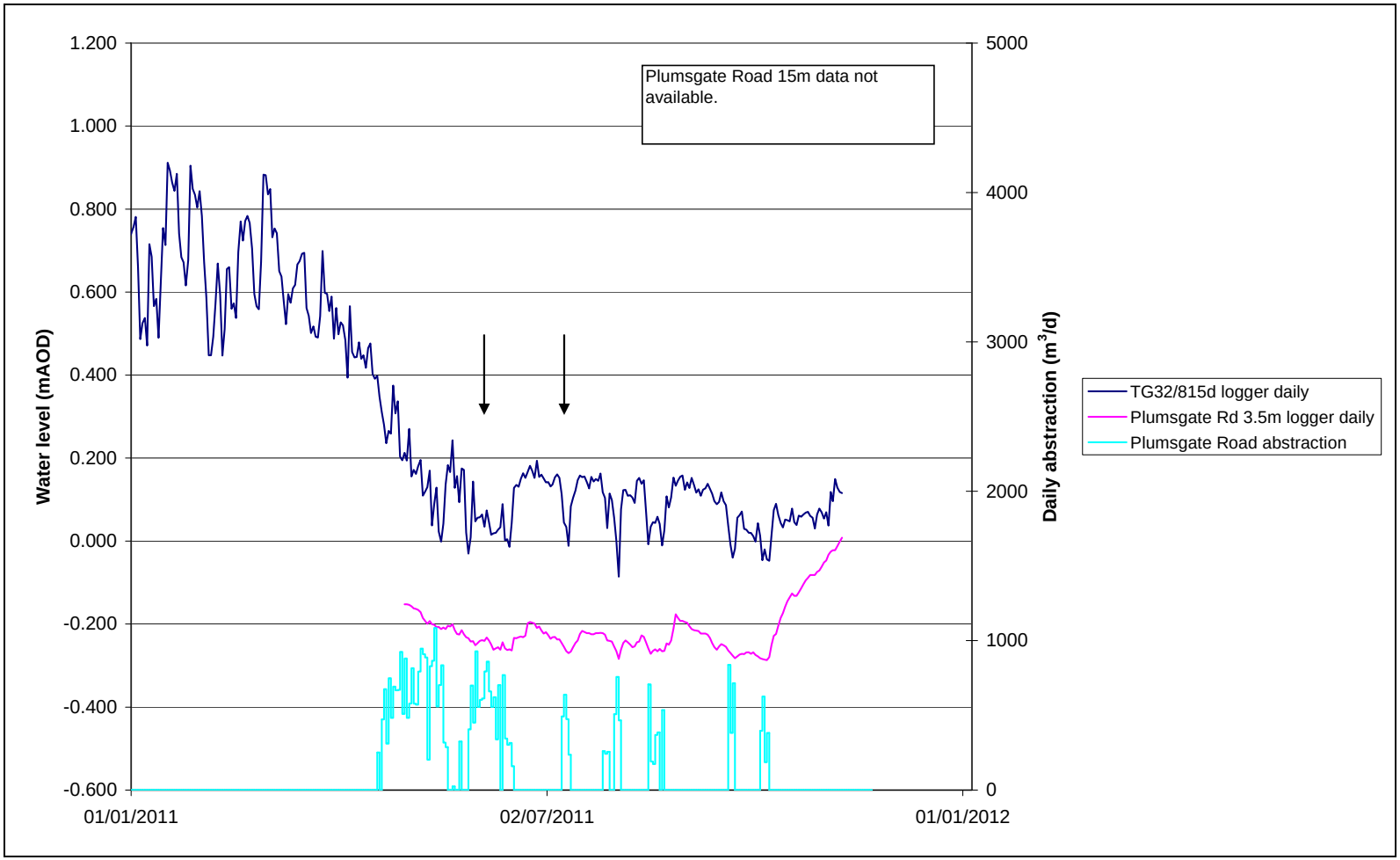


Figure E45 – Daily abstraction from the Plumsgate Road borehole in 2011 with water level data from nearby boreholes
(Arrows indicate abstraction periods referred to in Table 7.1)

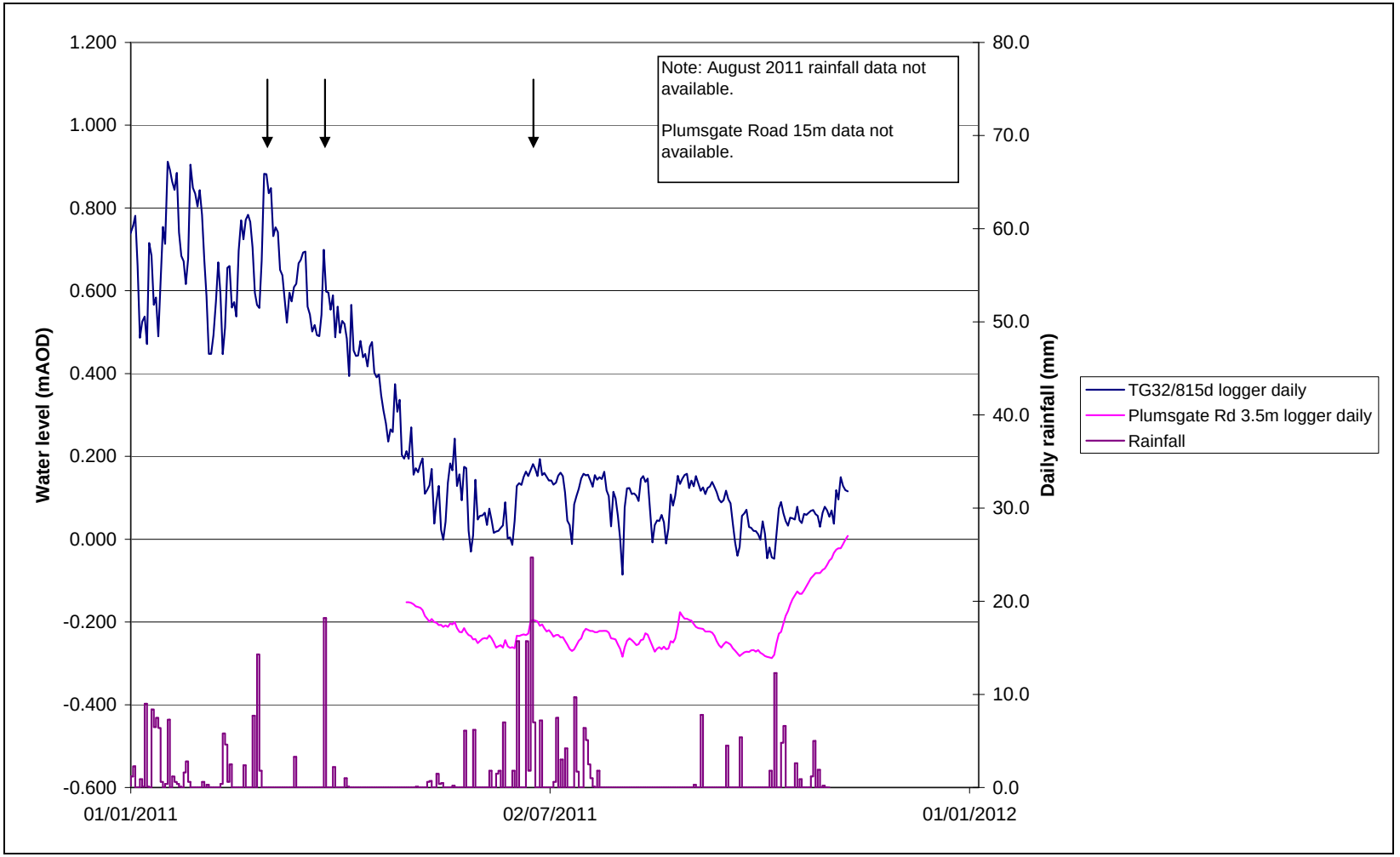


Figure E46 – Daily rainfall in 2011 with water level data from boreholes in the vicinity of the Plumsgate Road abstraction (Arrows refer to a selection of rainfall events)

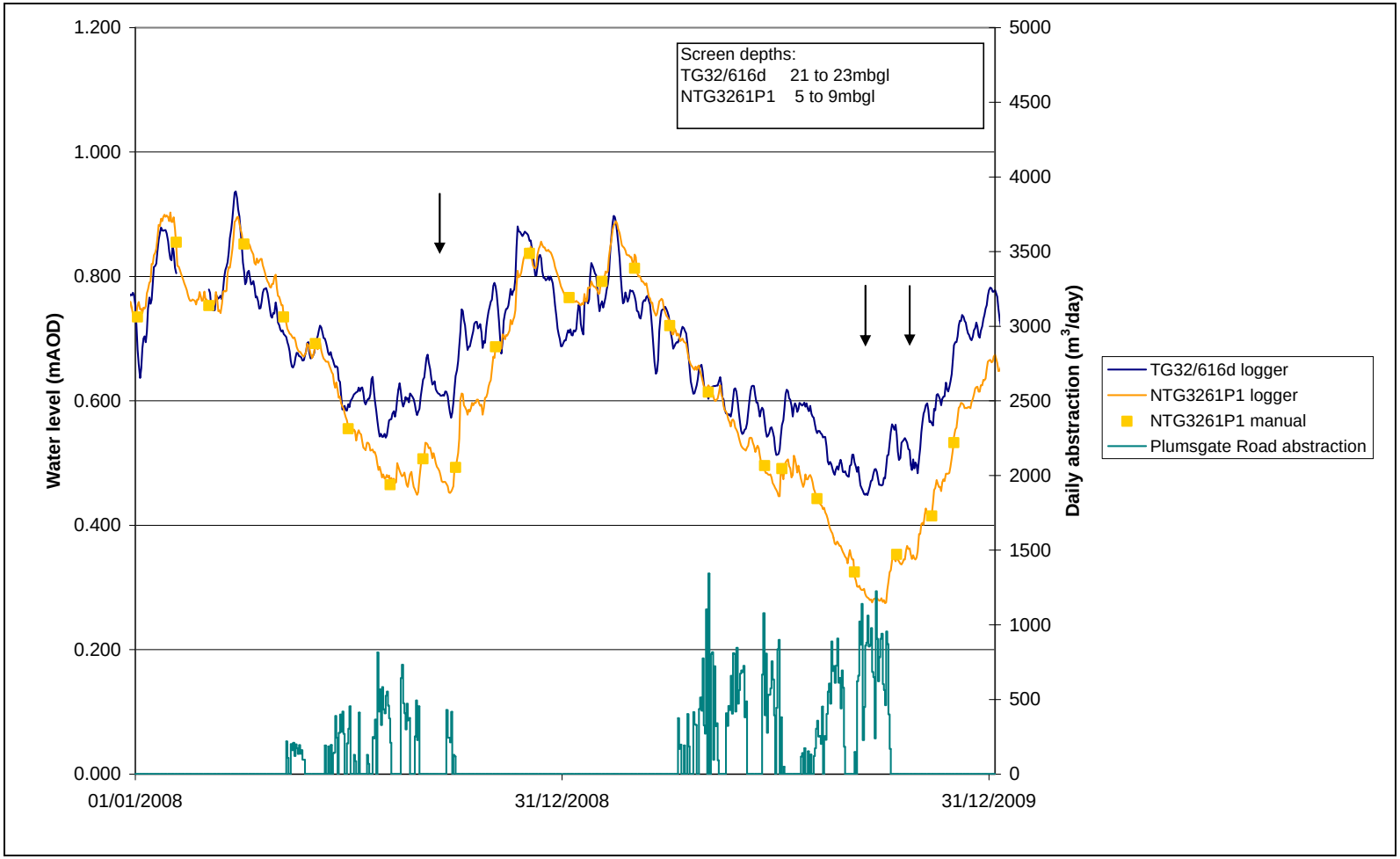


Figure E47 – Daily abstraction data from the Plumsgate Road borehole for 2008 and 2009 with groundwater levels from boreholes in the NW corner of Catfield Fen (Arrows point to groundwater level declines referred to in Section 7.2.1. Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

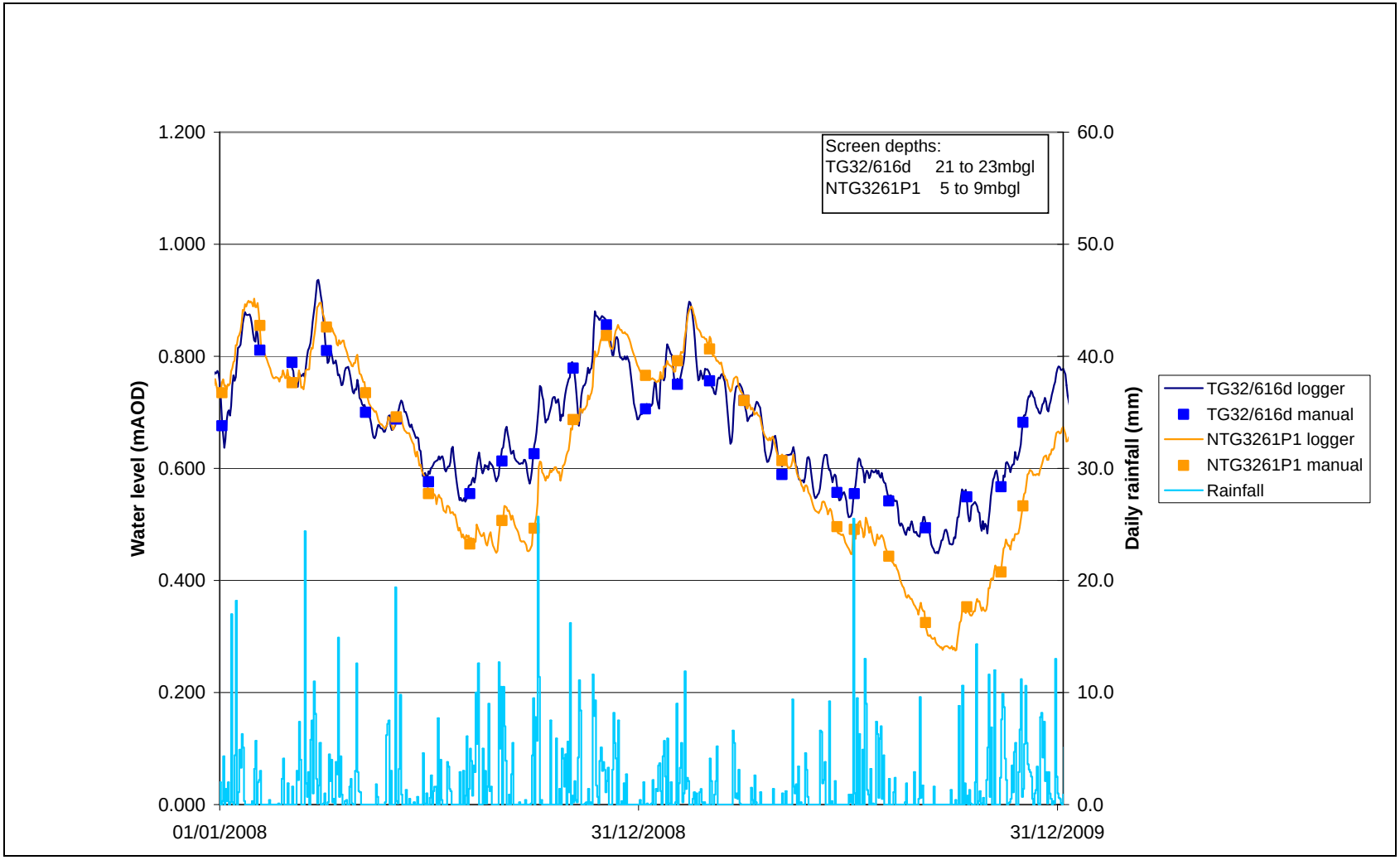


Figure E48 – Daily rainfall data for 2008 and 2009 with groundwater levels from boreholes in the NW corner of Catfield Fen

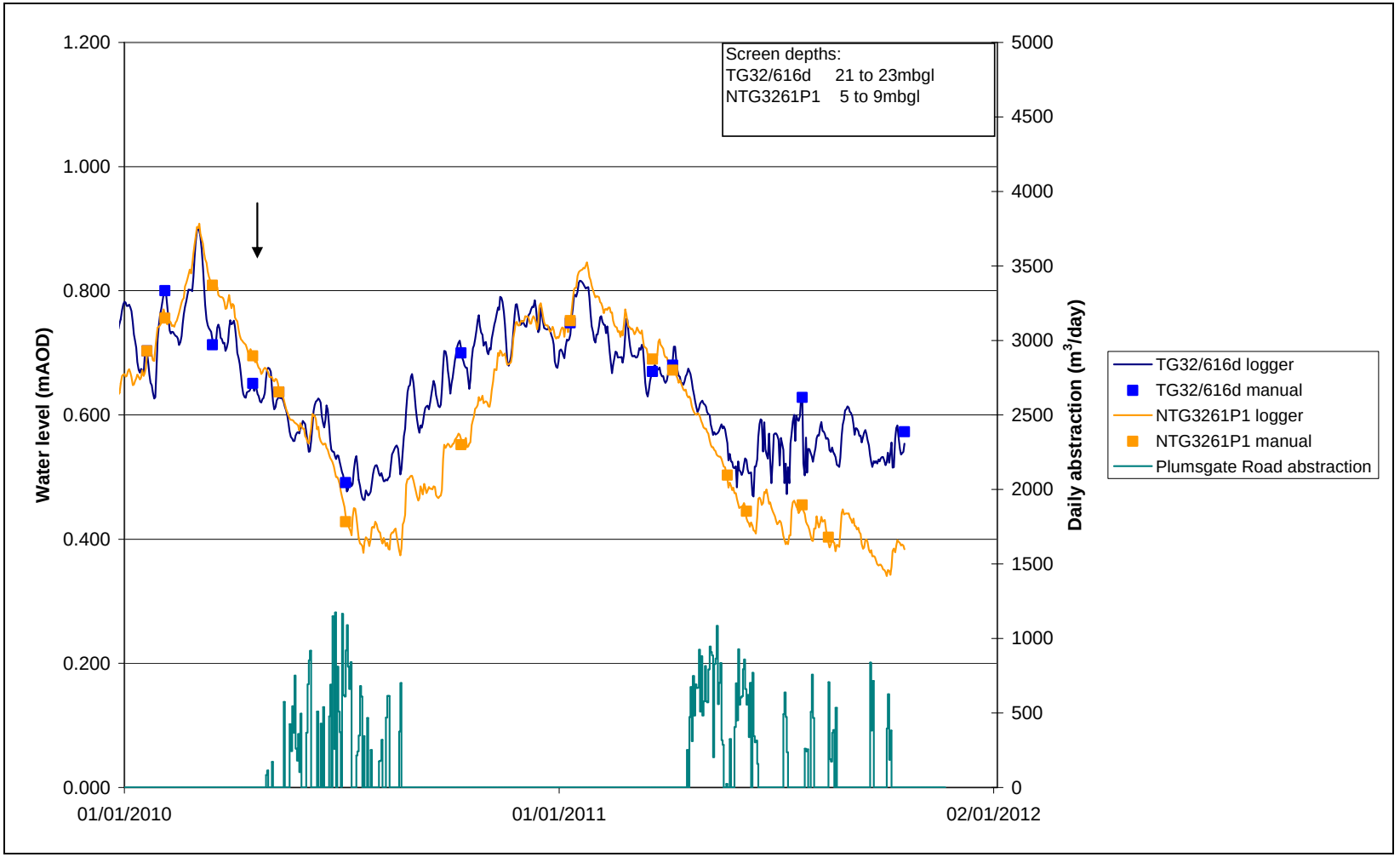


Figure E49 – Daily abstraction data from the Plumsgate Road borehole for 2010 and 2011 with groundwater levels from boreholes in the NW corner of Catfield Fen (Arrow points to groundwater level decline referred to in Section 7.2.1)

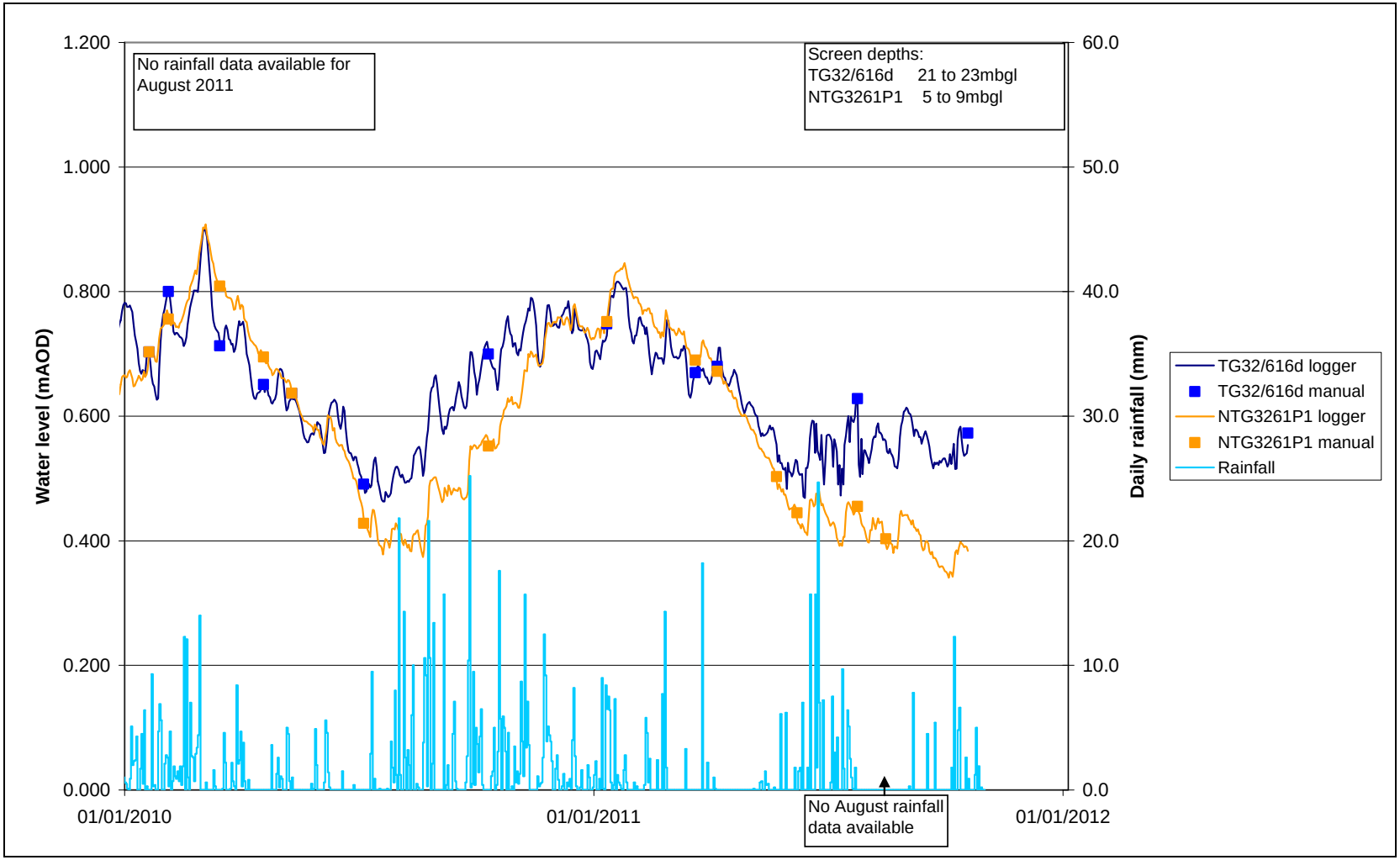


Figure E50 – Daily rainfall data for 2010 and 2011 with groundwater levels from boreholes in the NW corner of Catfield Fen

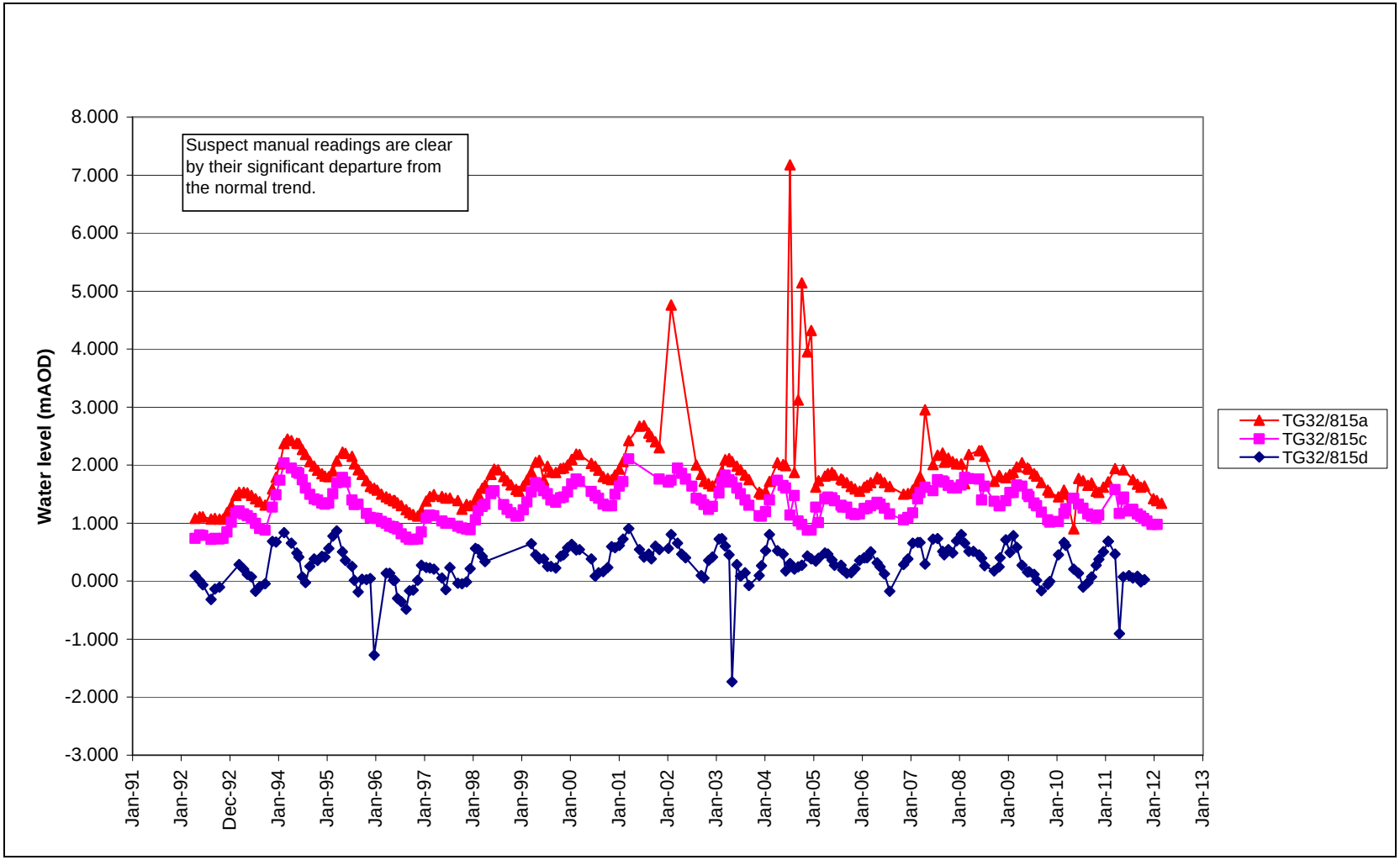


Figure E51 – Manual water level data from TG32/815d near the Plumsgate Road abstraction, and from two other boreholes located between the abstraction and Catfield Fen

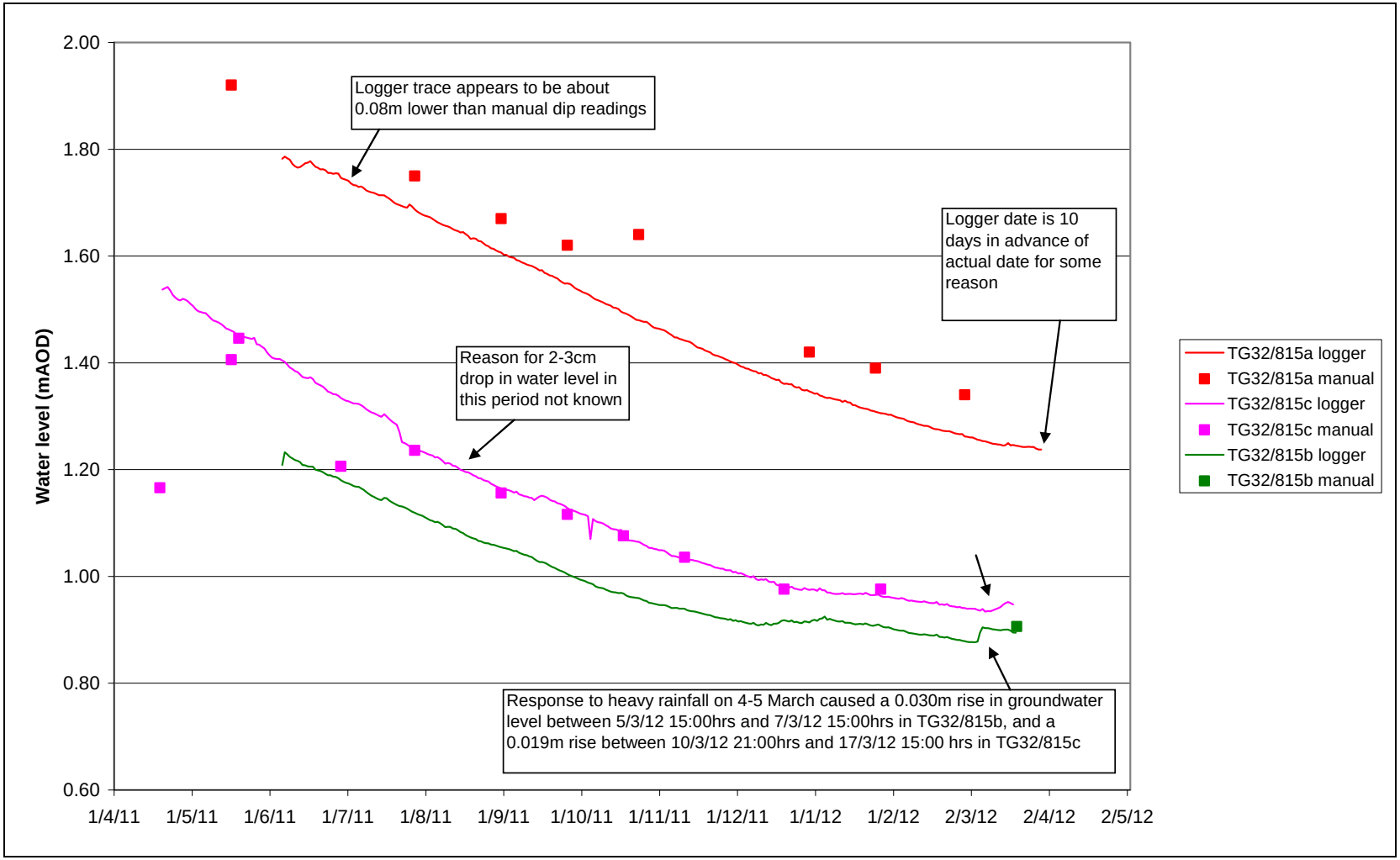


Figure E52 – Logger and manual water level data for 2011 from three boreholes located between the Plumsgate Road abstraction and Catfield Fen

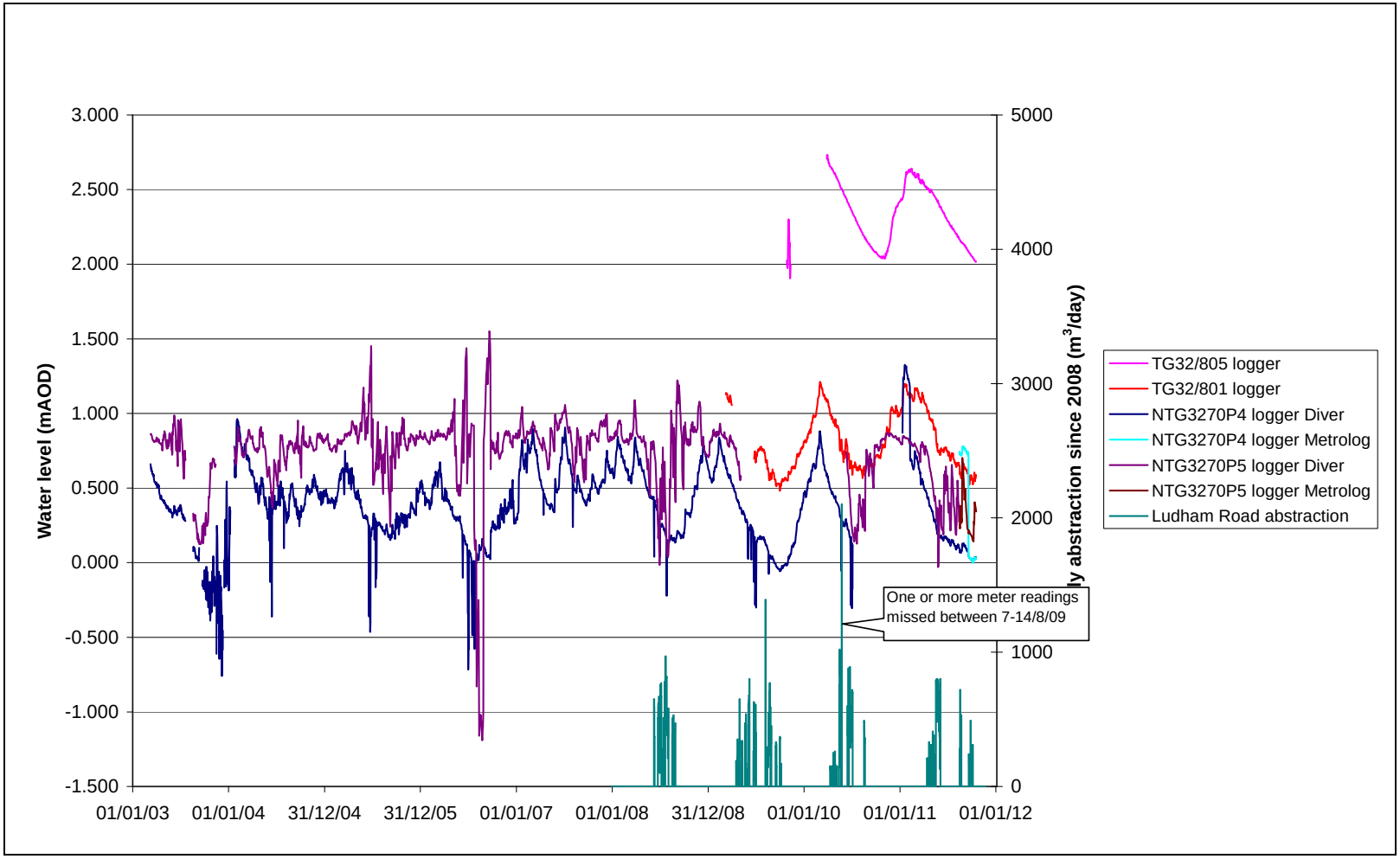


Figure E53 – Daily abstraction from the Ludham Road borehole (since 2008) with daily water level data from nearby boreholes
(Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

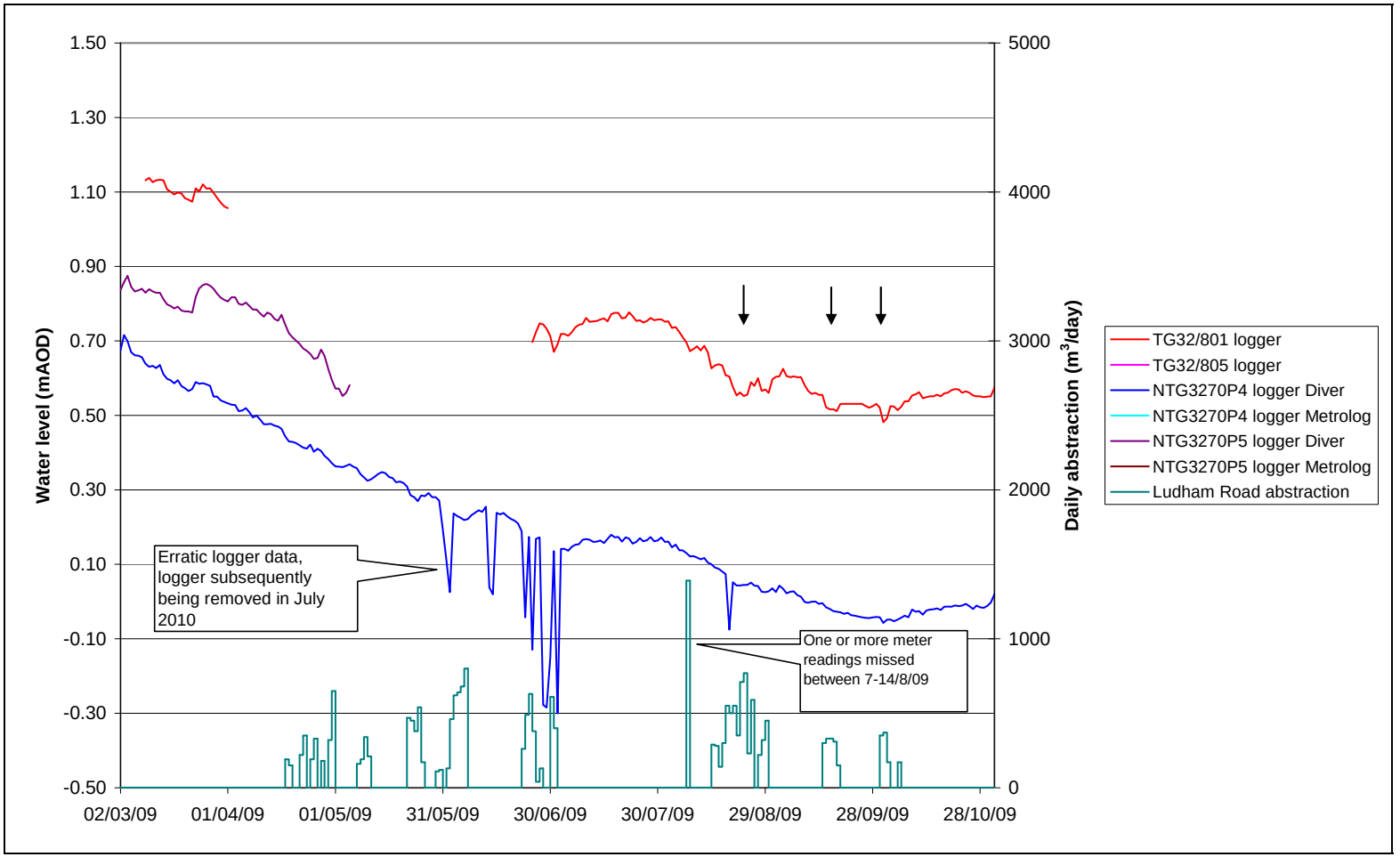


Figure E54 – Daily abstraction from the Ludham Road borehole in 2009 with daily water level data from nearby boreholes (Arrows point to groundwater level declines referred to in Table 7.2. Note: Increased vertical water level scale and that some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

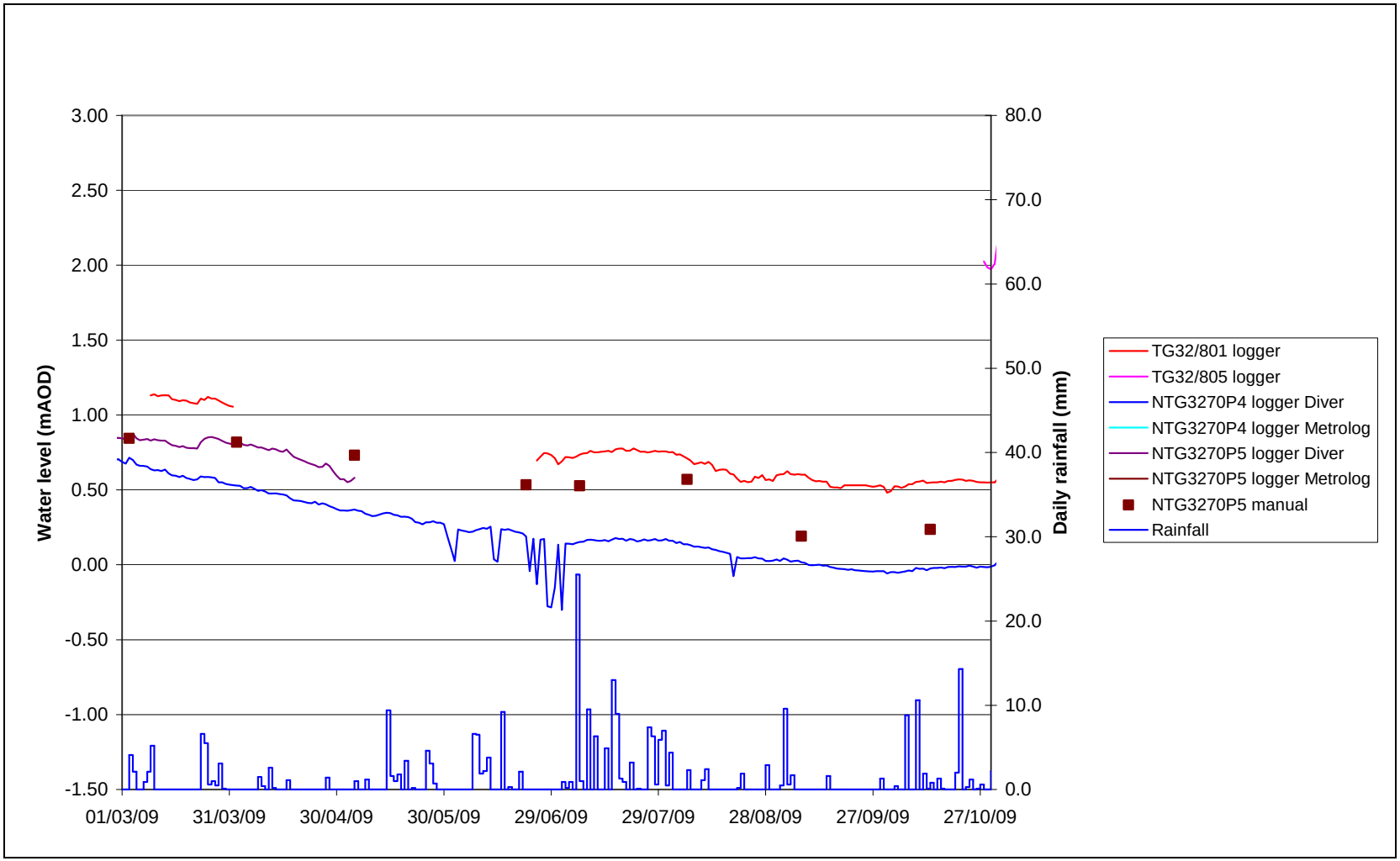


Figure E55 – Daily rainfall in 2009 with daily water level data from boreholes in the vicinity of the Ludham Road abstraction

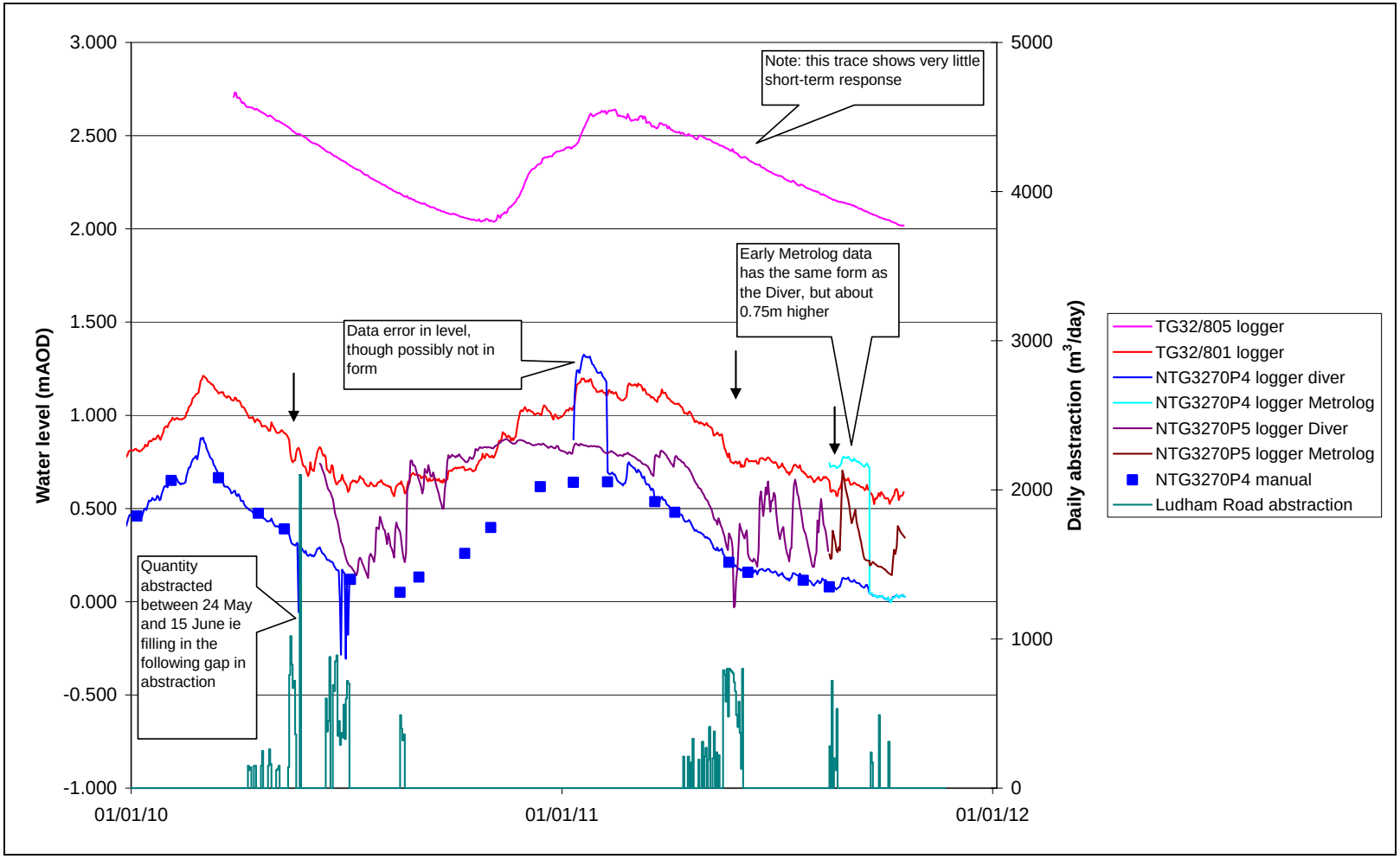


Figure E56 – Daily abstraction from the Ludham Road borehole in 2010 and 2011 with daily water level data from nearby boreholes (Arrows point to groundwater level declines referred to in Table 7.2. Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

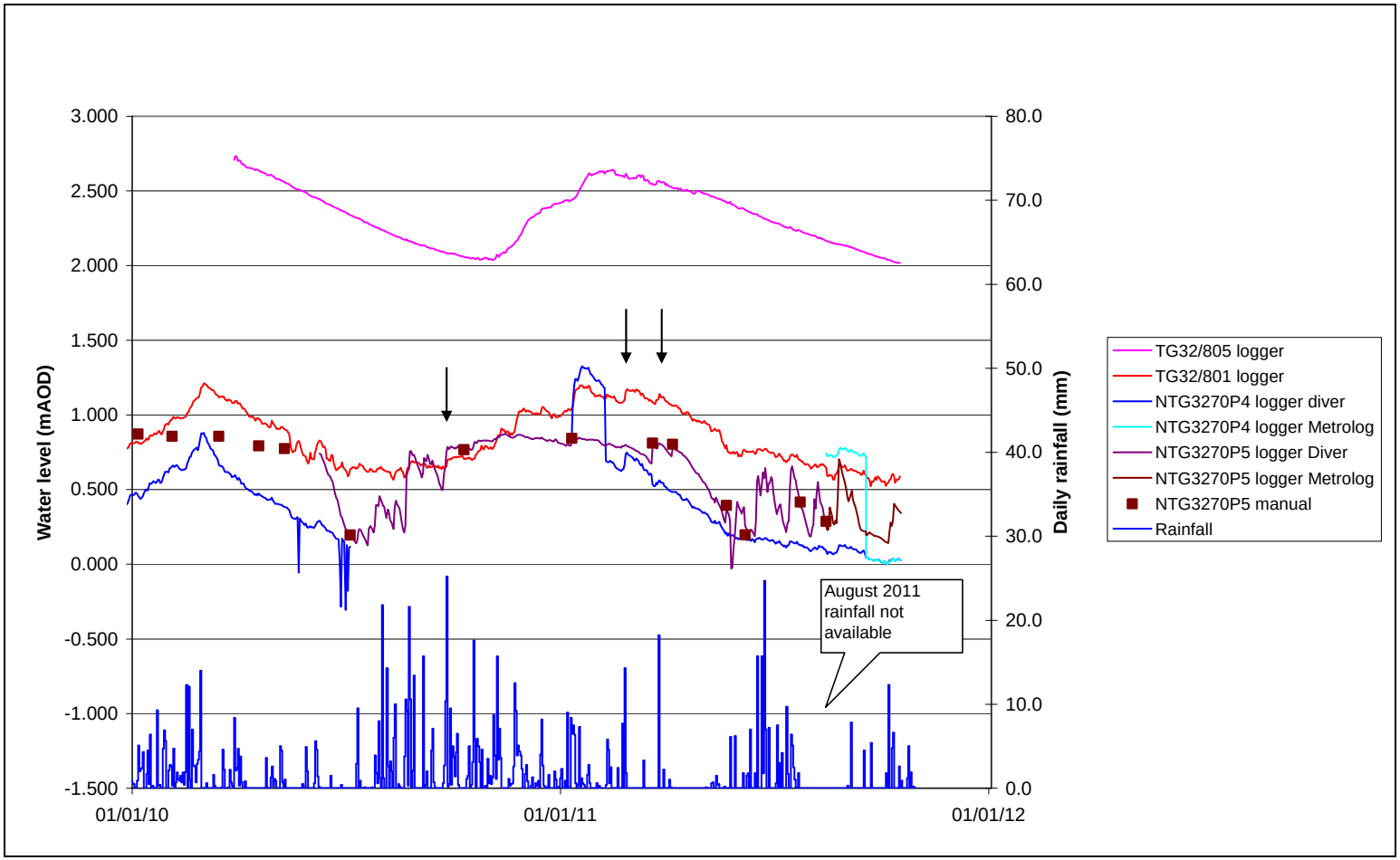


Figure E57 – Daily rainfall in 2010 and 2011 with daily water level data from boreholes in the vicinity of the Ludham Road abstraction (Arrows point to rainfall events referred to in Section 7.2.2)

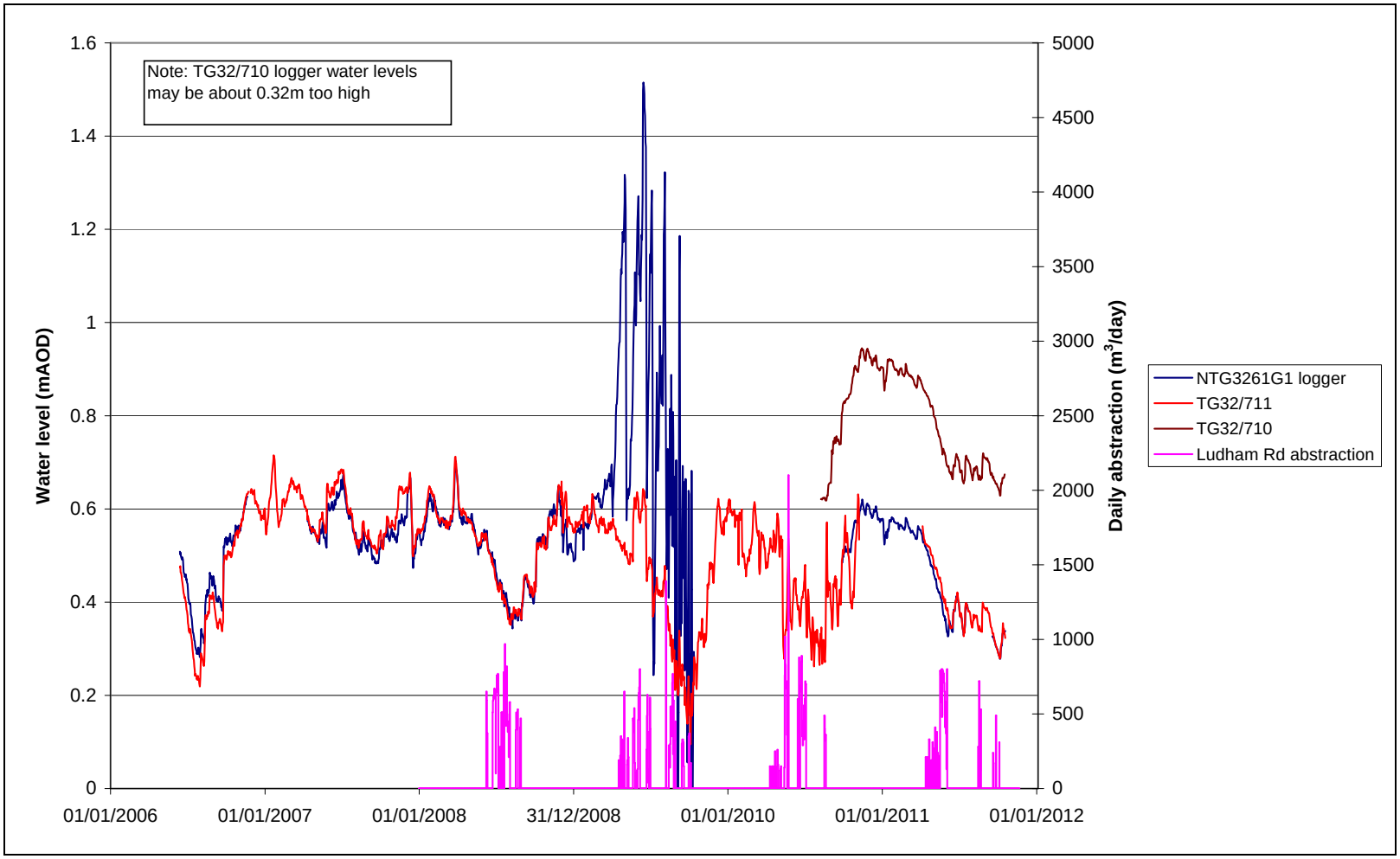


Figure E58– Daily abstraction data from the Ludham Road borehole (since 2008) with water level data from the internal system (Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period)

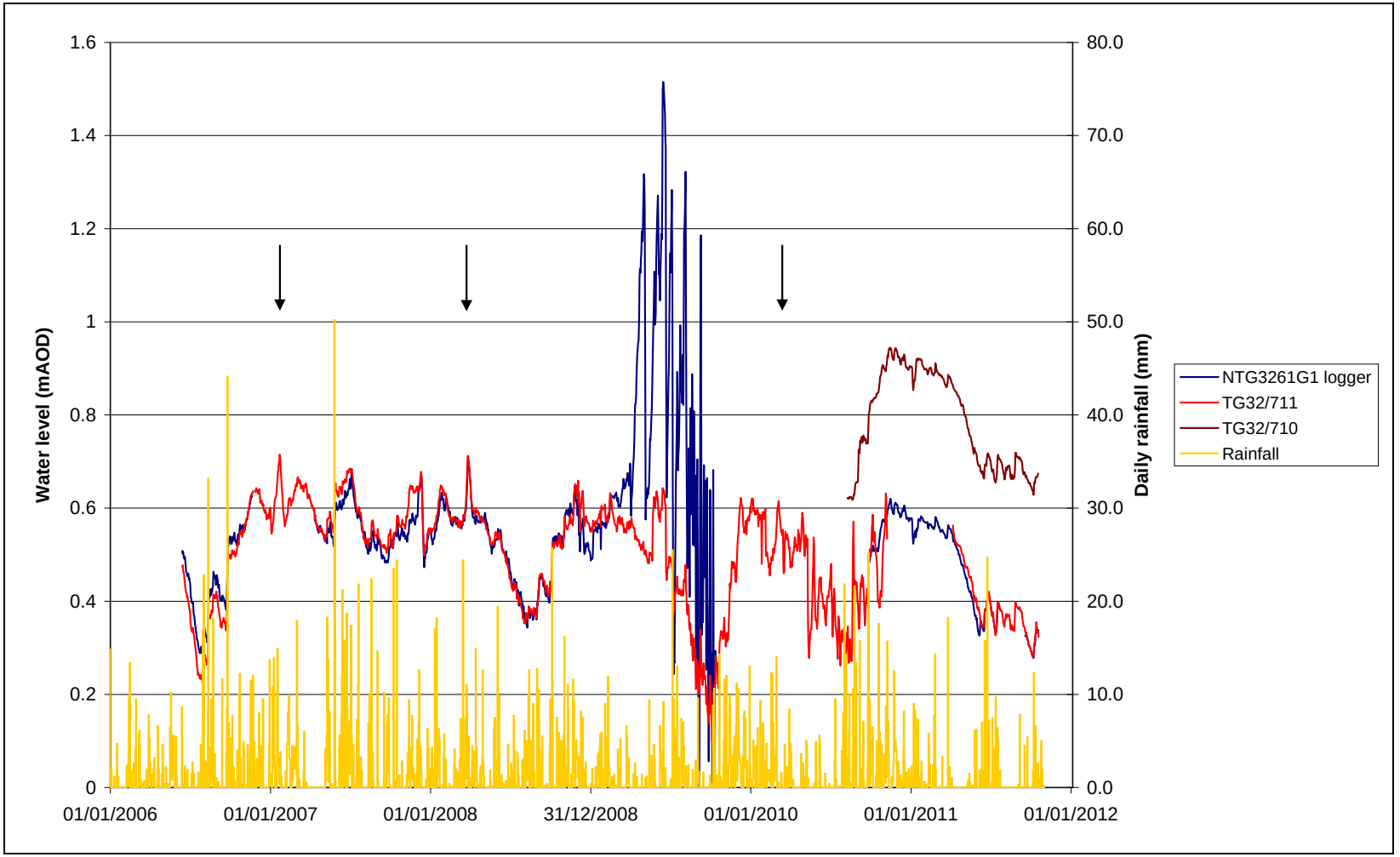


Figure E59 – Daily rainfall from 2006-2011 with water level data from the internal system (Arrows point to selected water level peaks related to rainfall events)

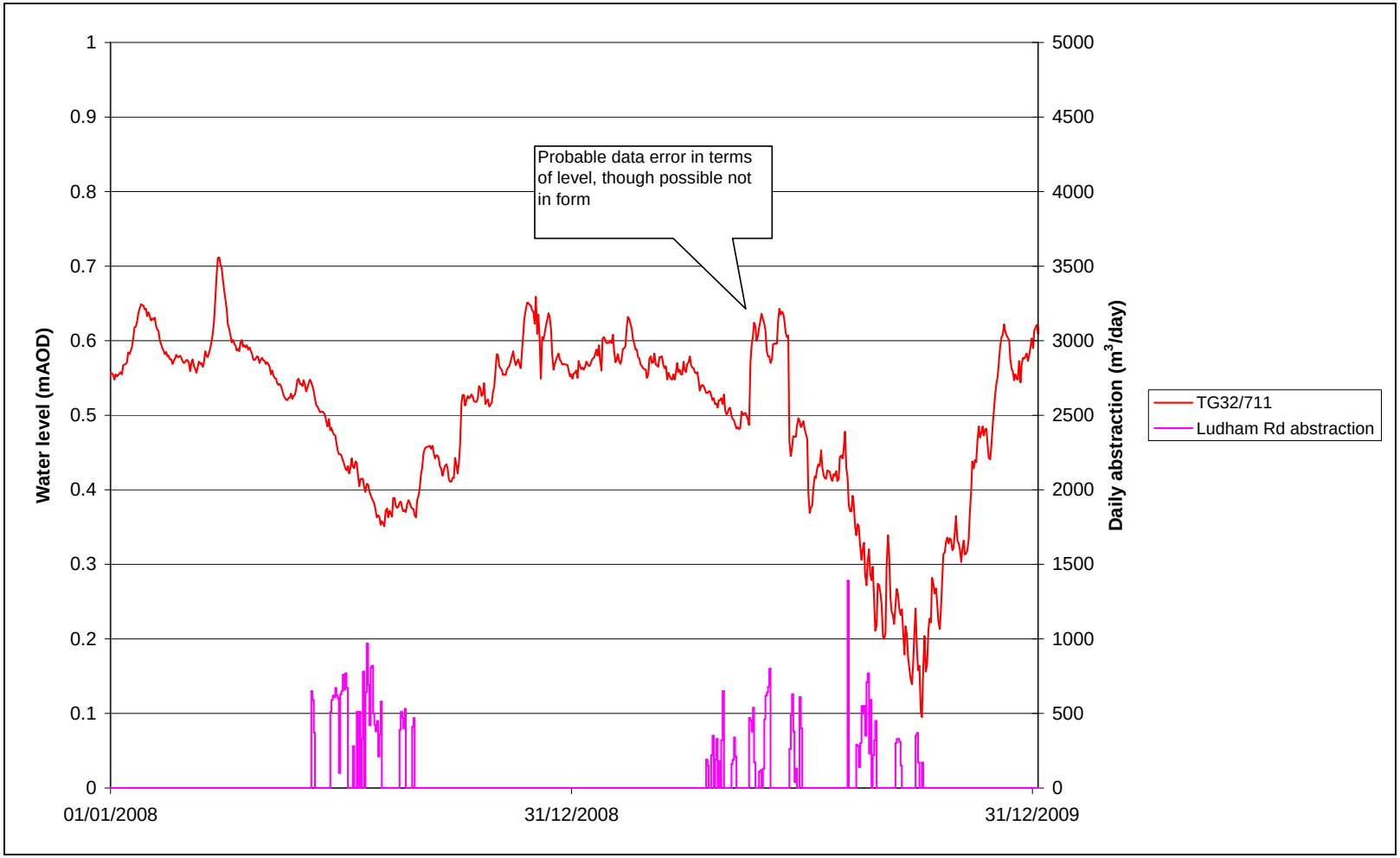


Figure E60 – Daily abstraction data from the Ludham Road borehole in 2008 and 2009, with dyke water level data representative of the internal system (Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period; see also Fig. E53)

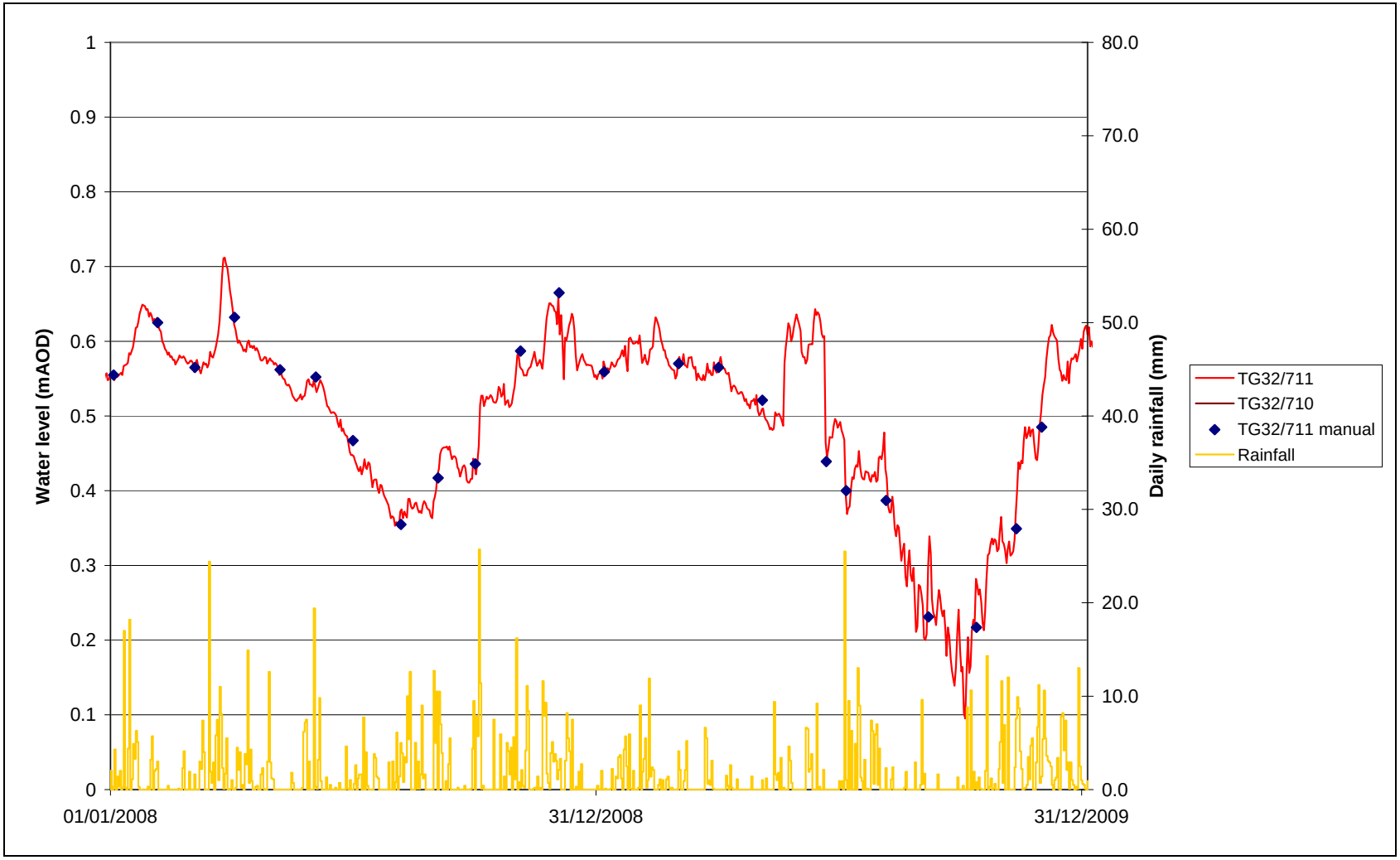


Figure E61 – Daily rainfall data for 2008 and 2009, with dyke water level data representative of the internal system

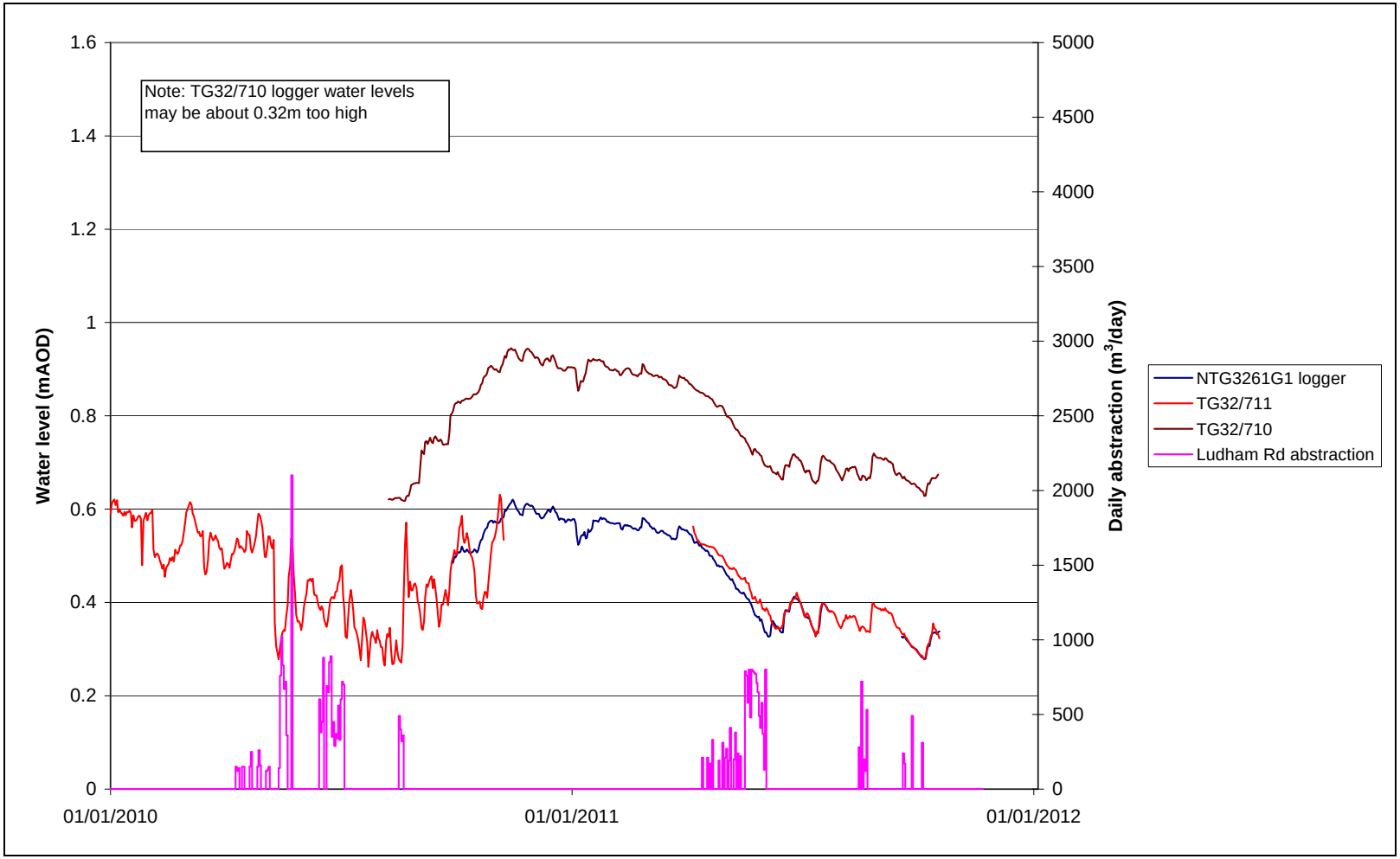


Figure E62 – Daily abstraction data from the Ludham Road borehole in 2010 and 2011, with dyke water level data representative of the internal system (Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period; see also Fig. E53)

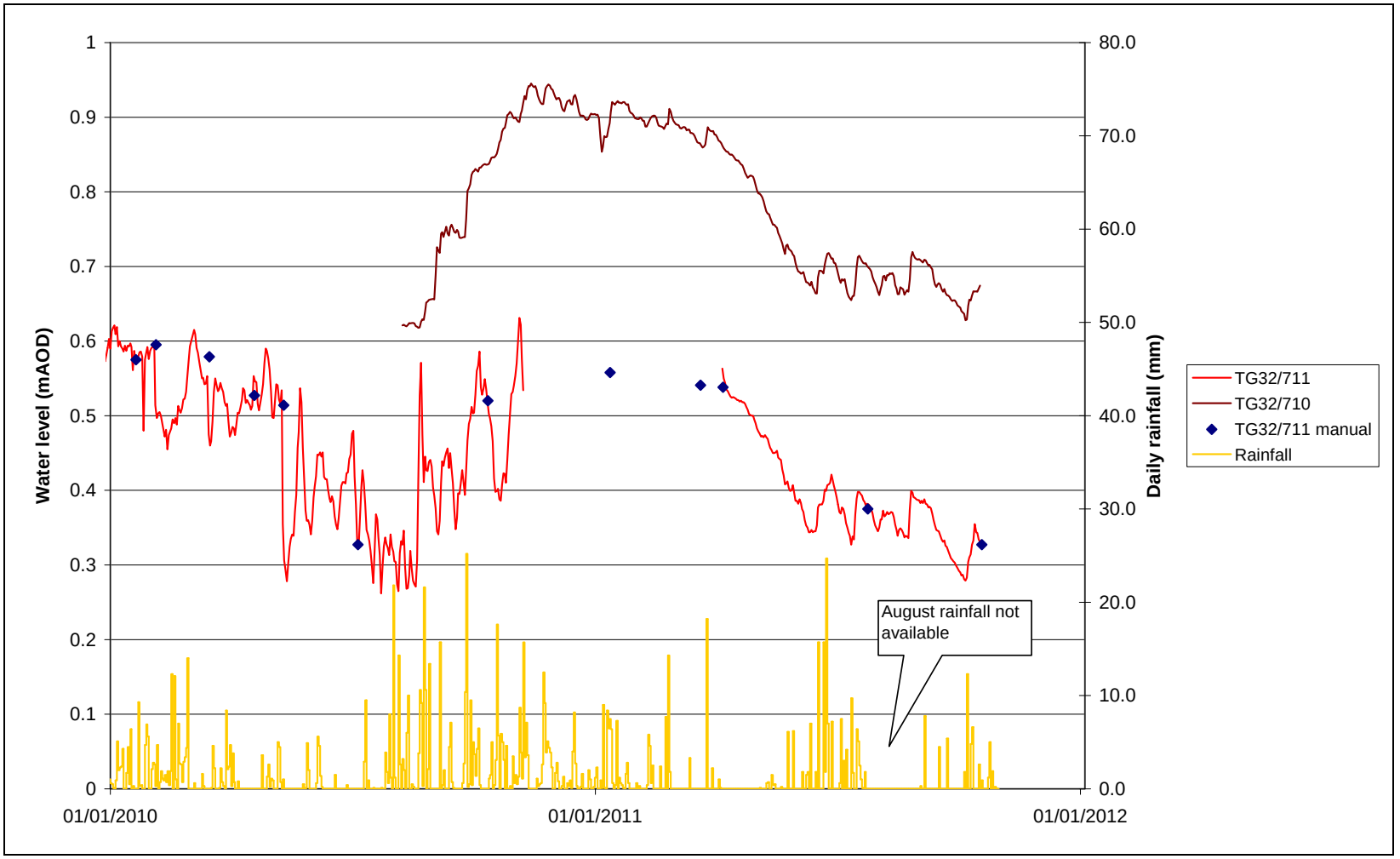


Figure E63 – Daily rainfall data for 2010 and 2011, with dyke water level data representative of the internal system

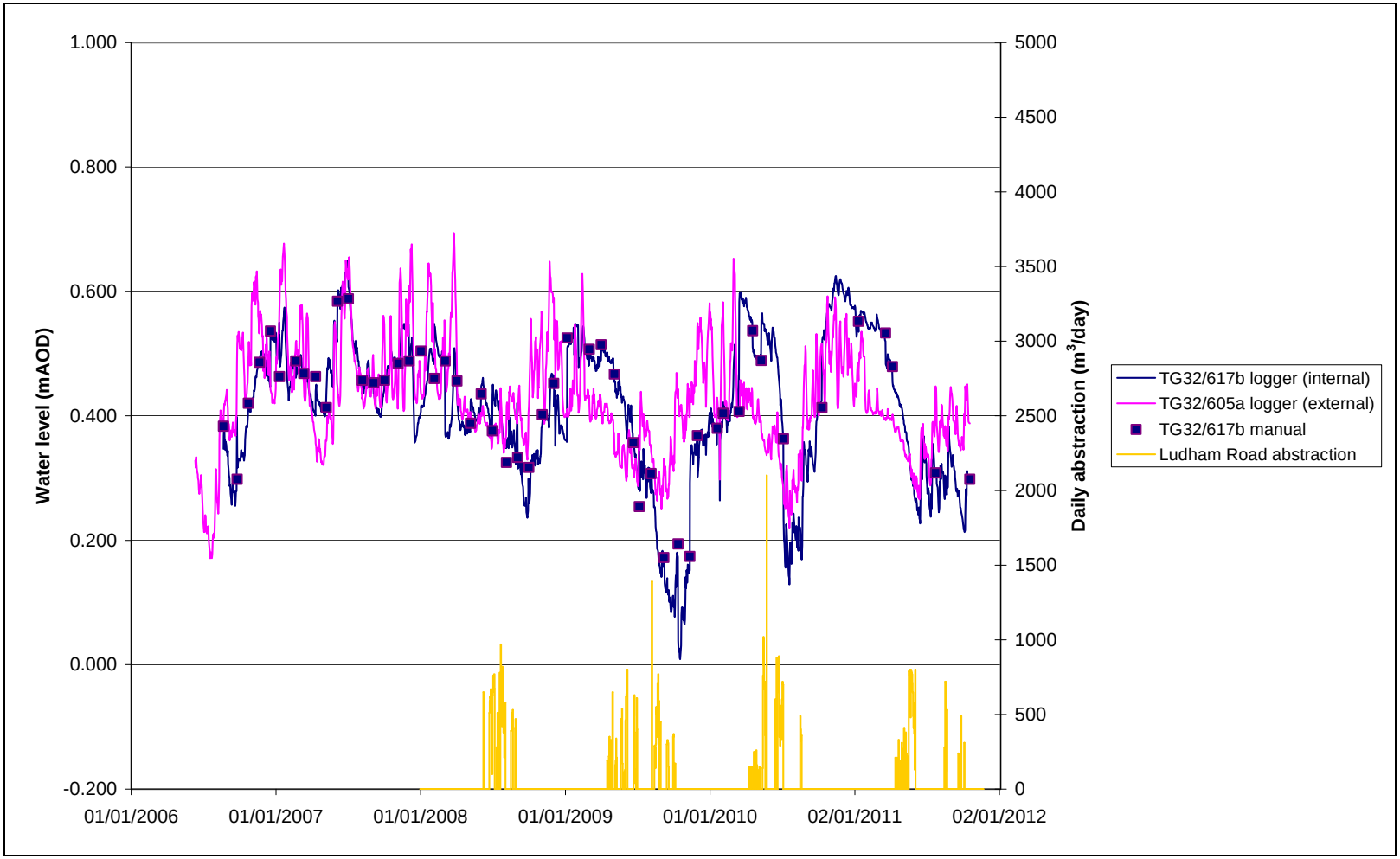


Figure E64 – Daily abstraction data from the Ludham Road borehole (since 2008) with water level data from dipwells on the western side of Catfield Fen in both the internal and external systems (Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period; see also Fig. E53)

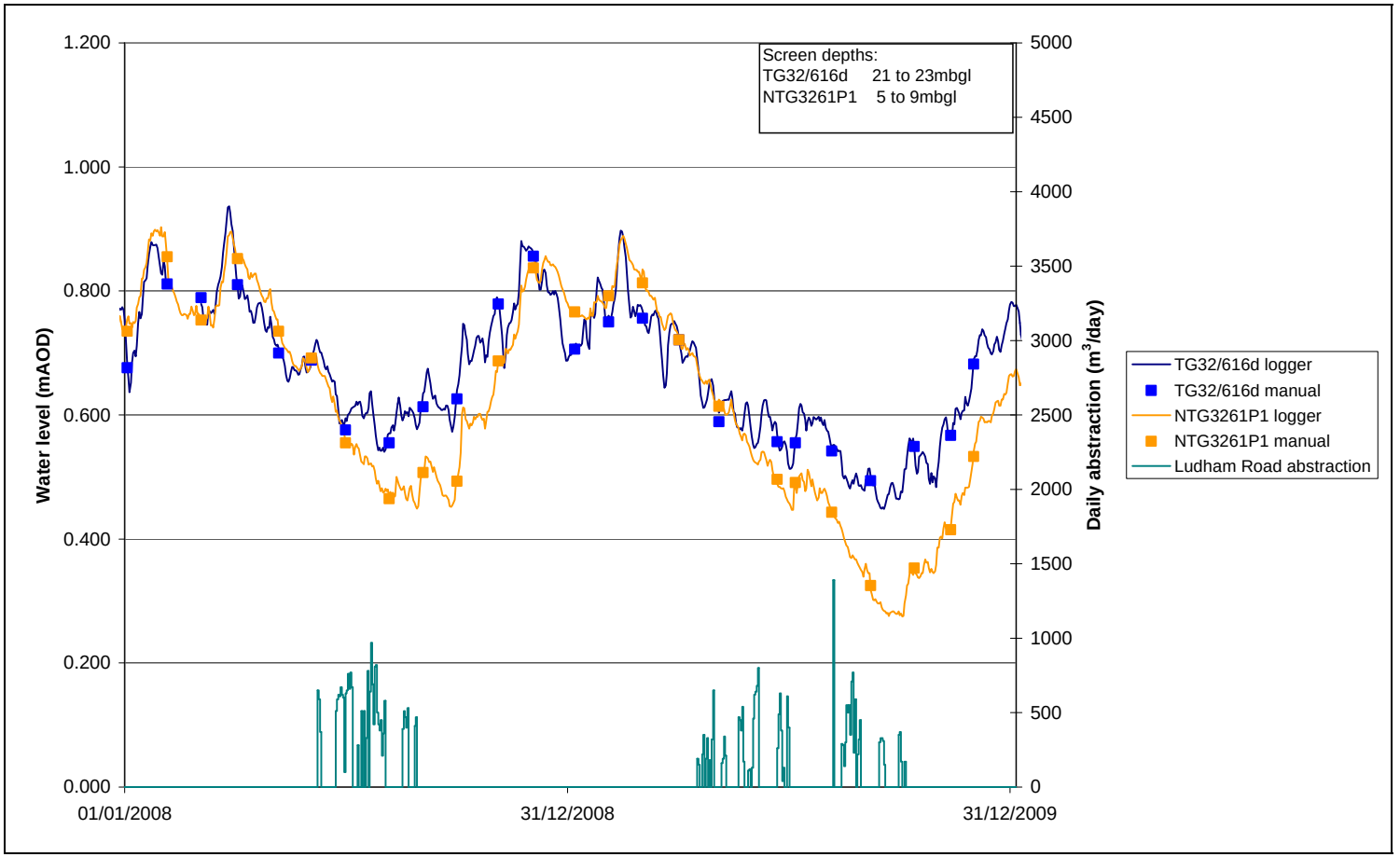


Figure E65 – Daily abstraction data from the Ludham Road borehole for 2008 and 2009 with groundwater levels from boreholes in the NW corner of Catfield Fen
(Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period; see also Fig. E53)

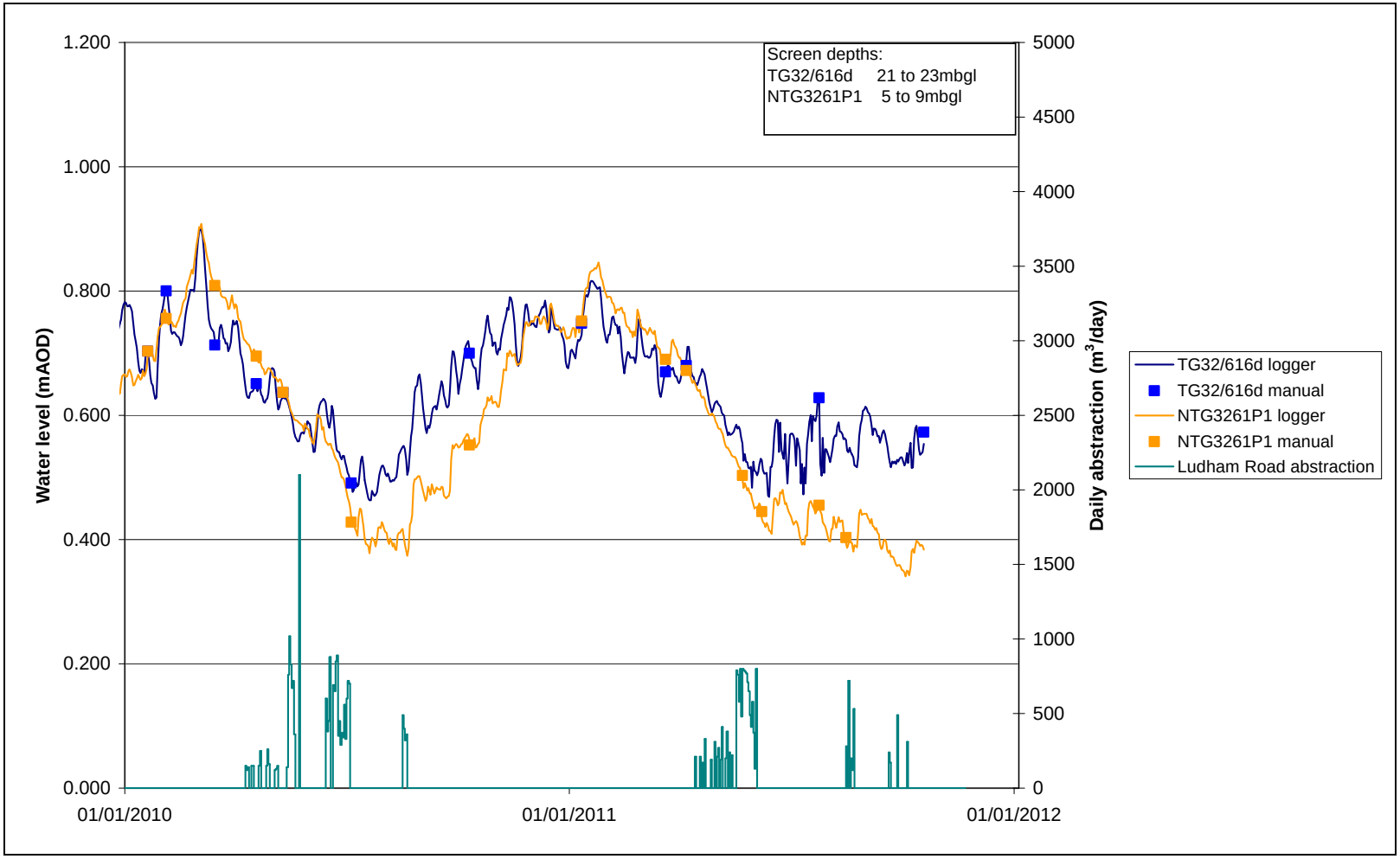


Figure E66 – Daily abstraction data from the Ludham Road borehole for 2010 and 2011 with groundwater levels from boreholes in the NW corner of Catfield Fen (Note: some abstractions which appear to be slightly above the daily licensed quantity include overnight pumping with the meter readings covering greater than a 24-hour period; see also Fig. E53)

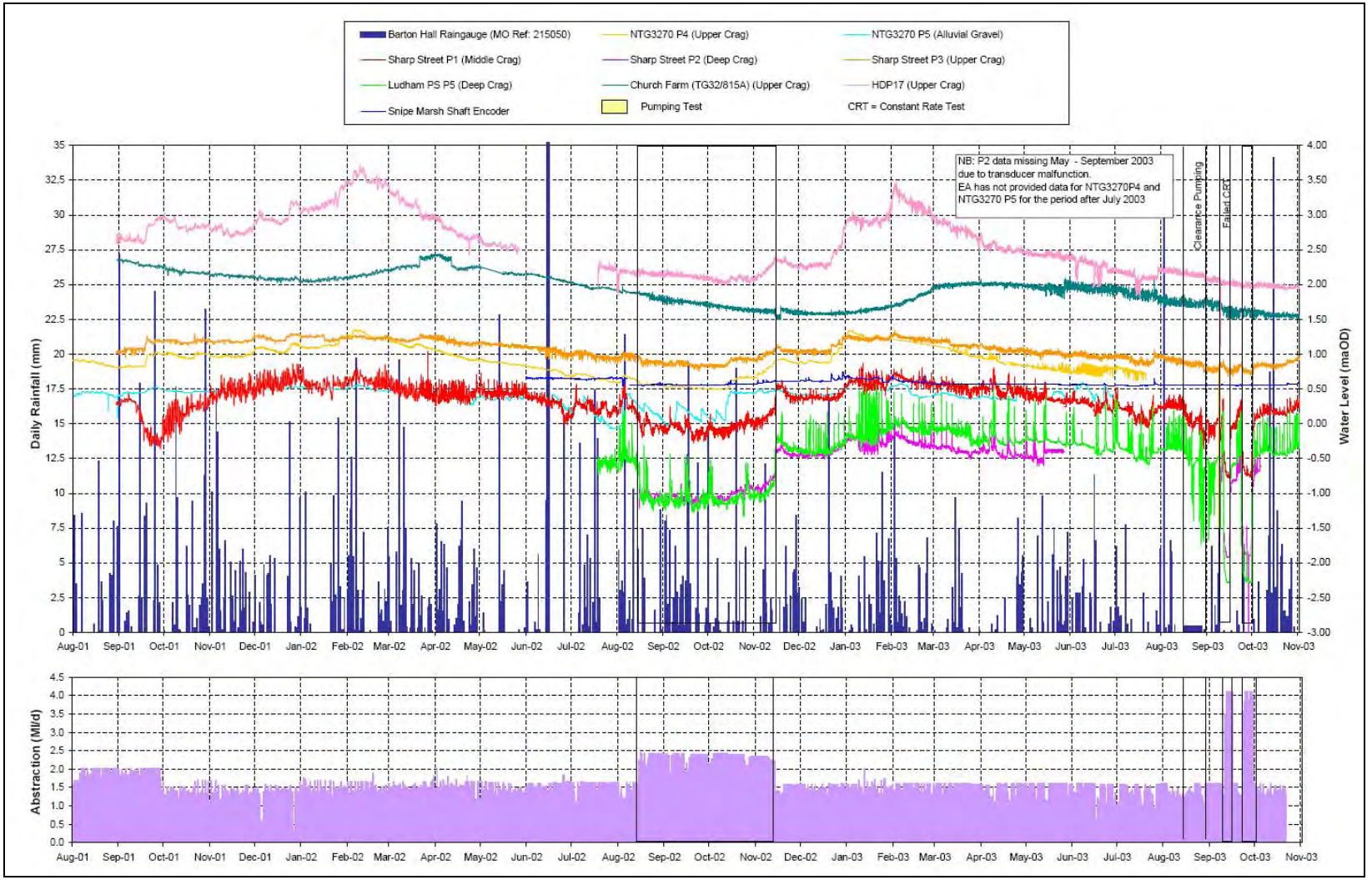


Figure E67 – Observation borehole hydrographs, rainfall and abstraction – August 2001 to November 2003 (from Atkins/HSI, 2003b, Fig. 9)

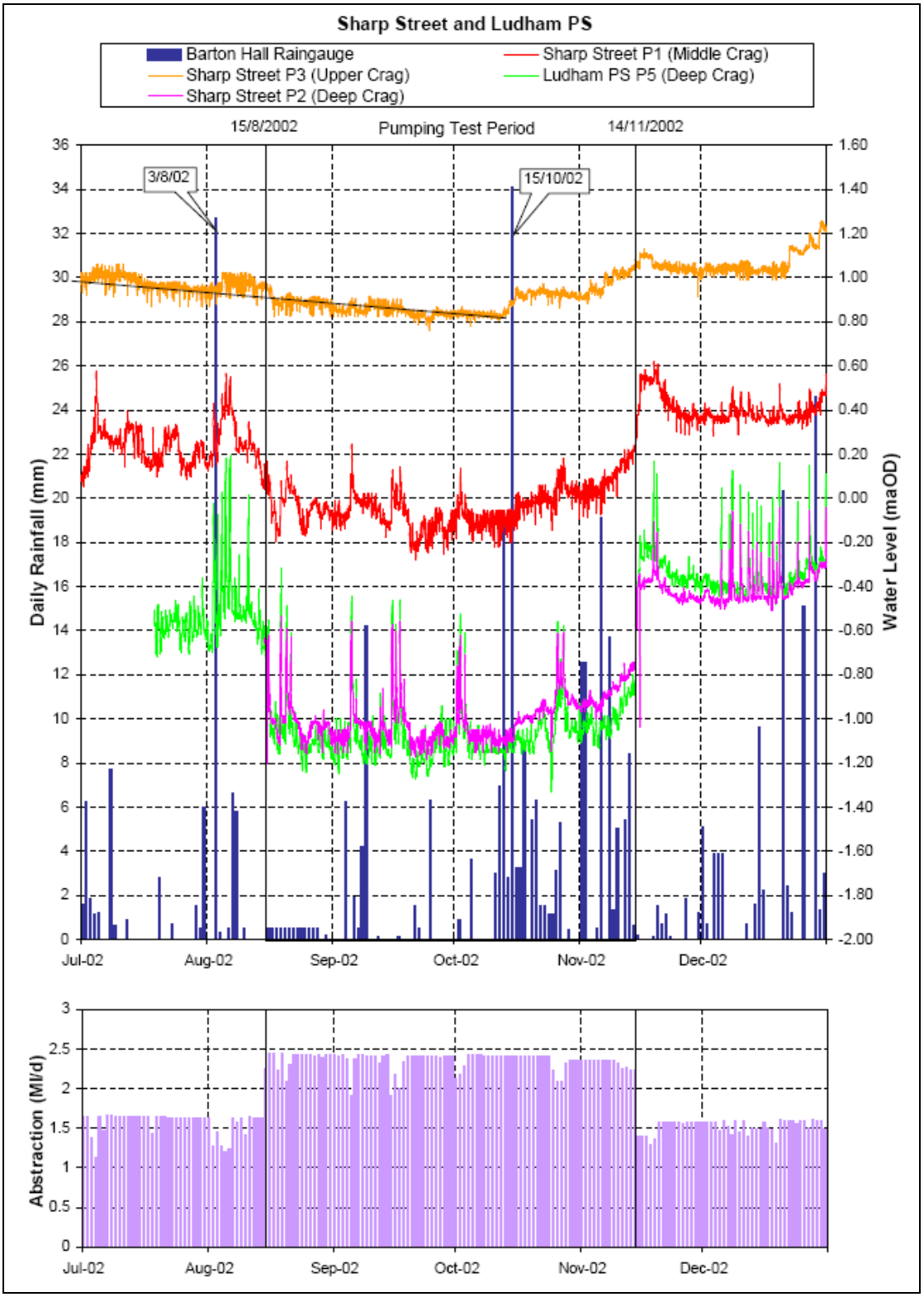


Figure E68 – Observation borehole hydrographs from the AWS Sharp Street observation boreholes and an observation borehole (P5) at the PWS source, with rainfall and abstraction, covering the period of the 2002 pumping test (from Atkins/HSI, 2003b, Fig. 10)

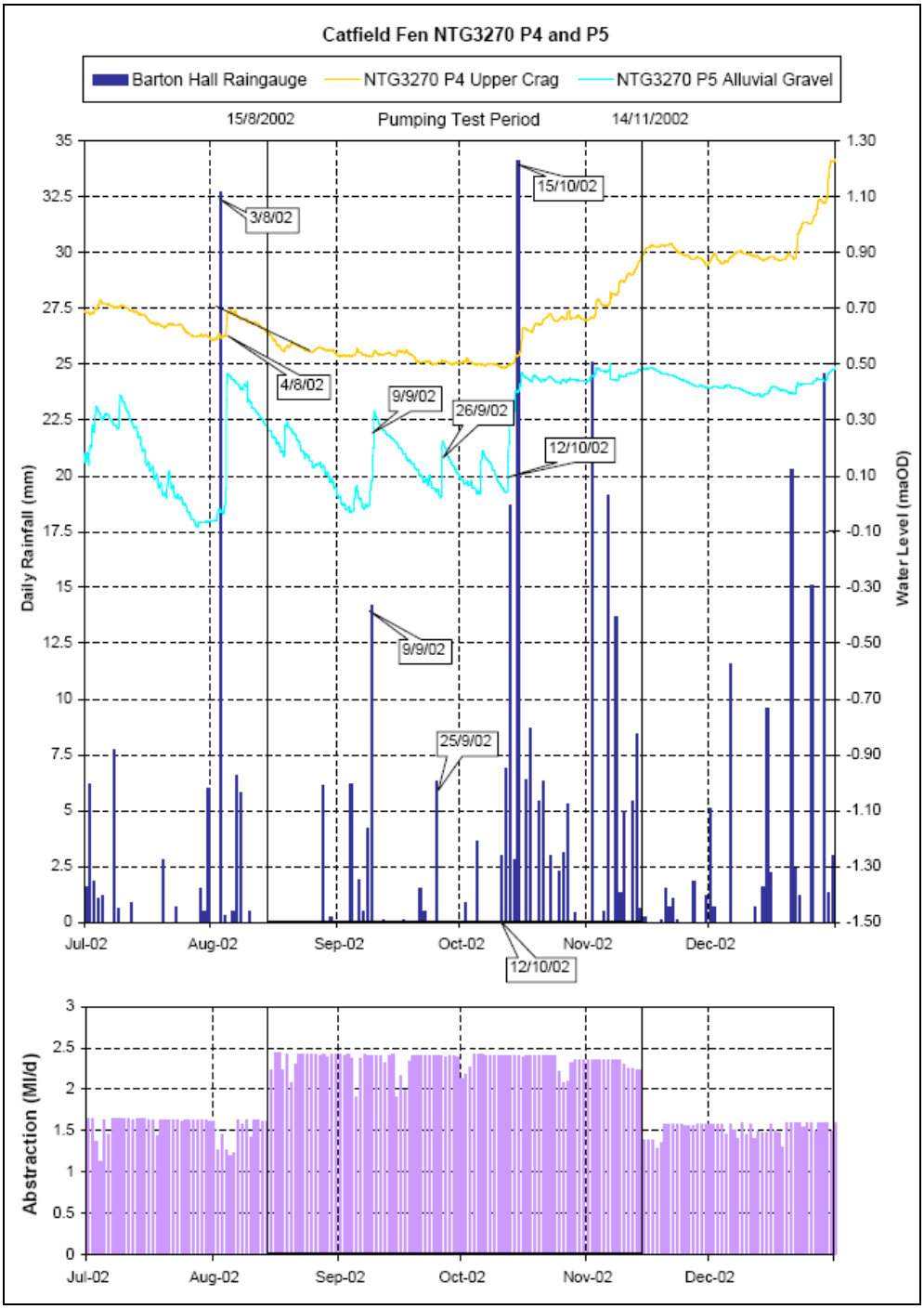


Figure E69 – Observation borehole hydrographs for NTG3270P4 and NTG3270P5 at Catfield Fen, with rainfall and abstraction, covering the period of the 2002 pumping test (from Atkins/HSI, 2003b, Fig. 11)

Note: the water levels are based on a past topographic survey undertaken by HSI in 1997. Recent 2011 survey data have resulted in significant changes in level, with the relationship between water levels in the two boreholes being reversed.

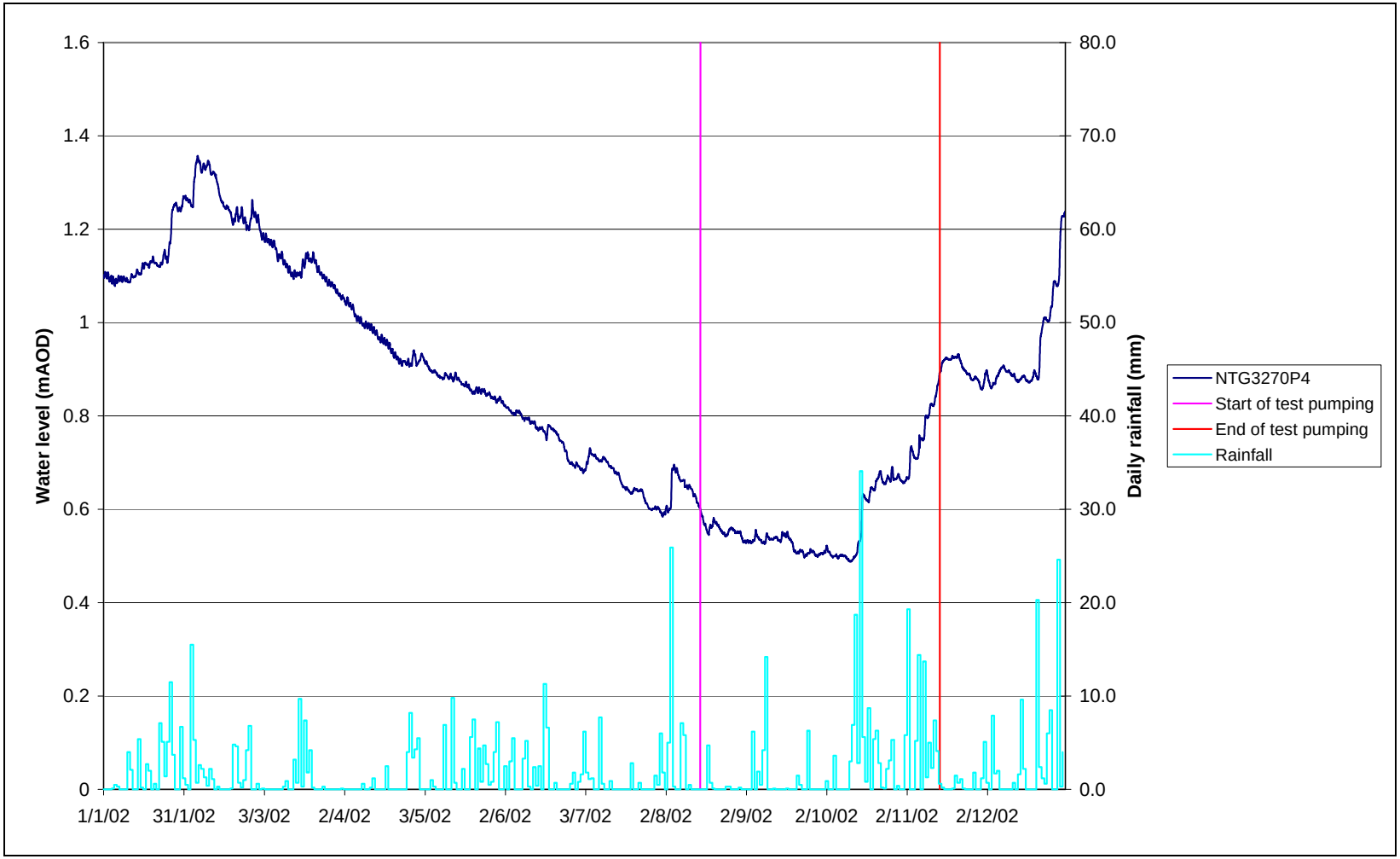


Figure E70 – Observation borehole hydrograph for NTG3270P4, with rainfall, covering the period of the 2002 pumping test (Note: the water level data were provided by AWS in mAOD, and therefore has not been amended to conform with the most recent topographic survey)

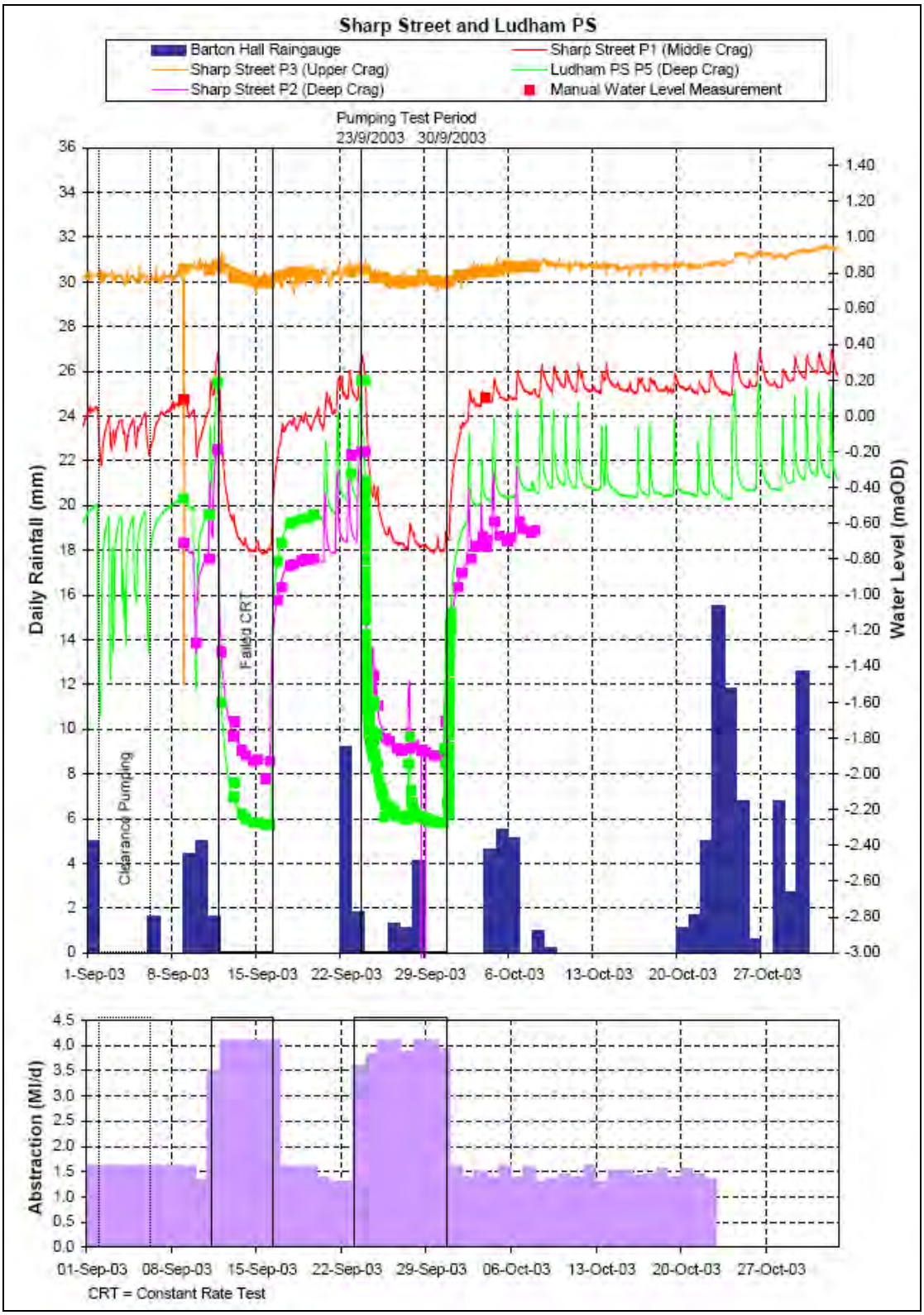


Figure E71 – Observation borehole hydrographs from the AWS Sharp Street observation boreholes and an observation borehole (P5) at the PWS source, with rainfall and abstraction, covering the period of the 2003 pumping test (from Atkins/HSI, 2003b, Fig. 14)

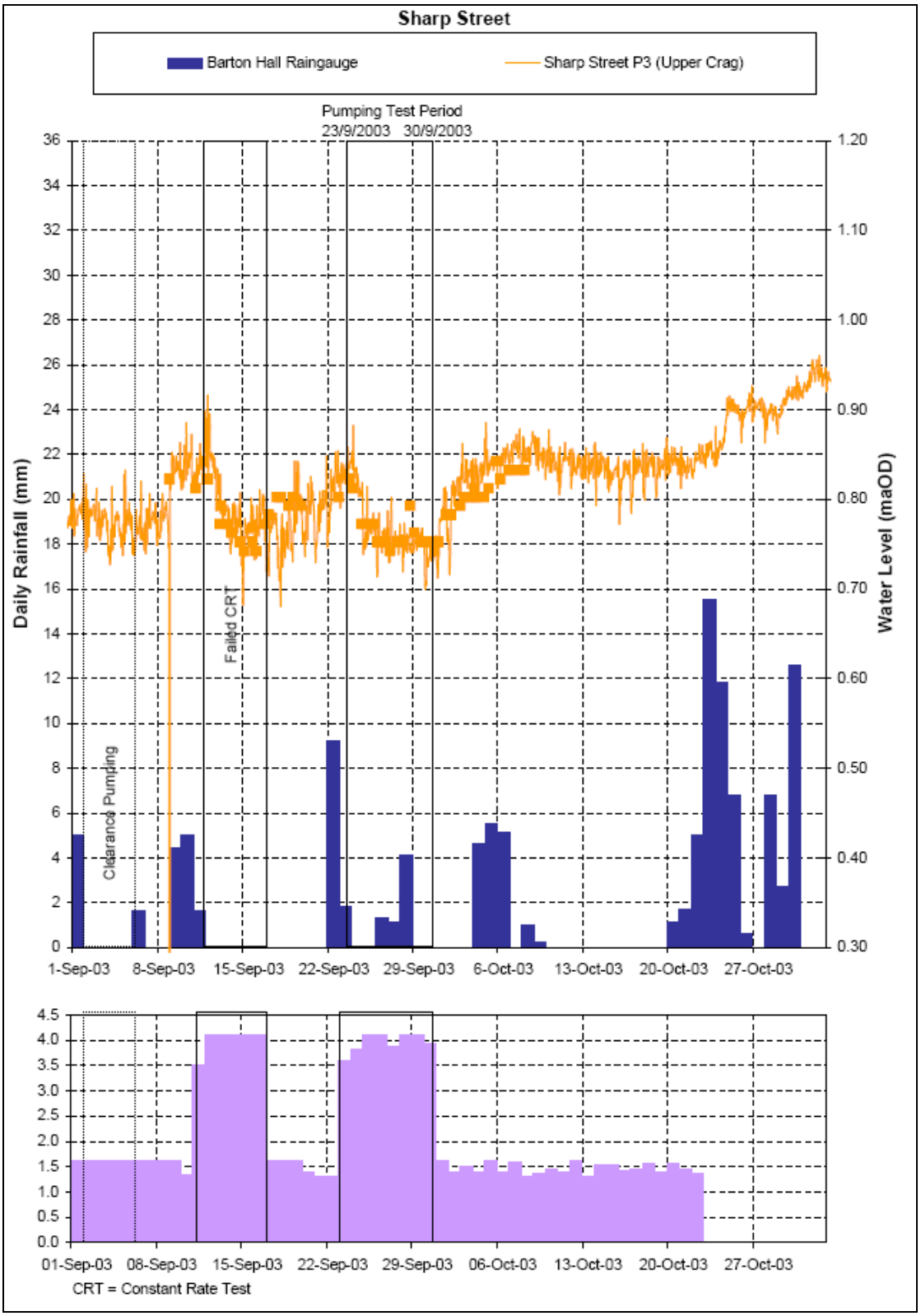


Figure E72 –Borehole hydrograph from the shallow Upper Crag observation borehole, AWS Sharp Street P5, with rainfall and abstraction, covering the period of the 2003 pumping test (from Atkins/HSI, 2003b, Fig. 16)

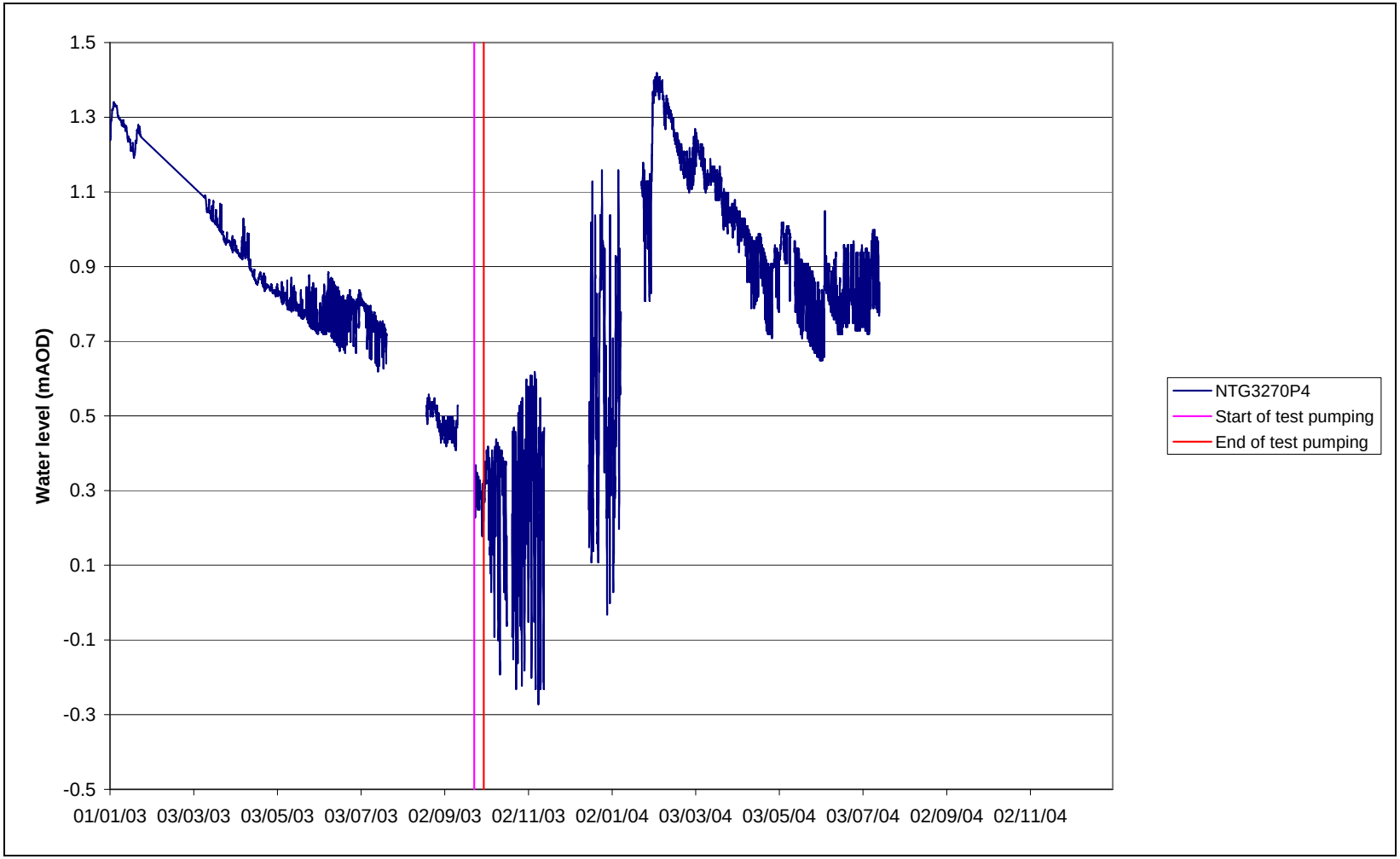


Figure E73 – Observation borehole hydrograph for NTG3270P4, covering the period 2003 and 2004. (Note: the water level data were provided by AWS in mAOD, and therefore has not been amended to conform with the most recent topographic survey

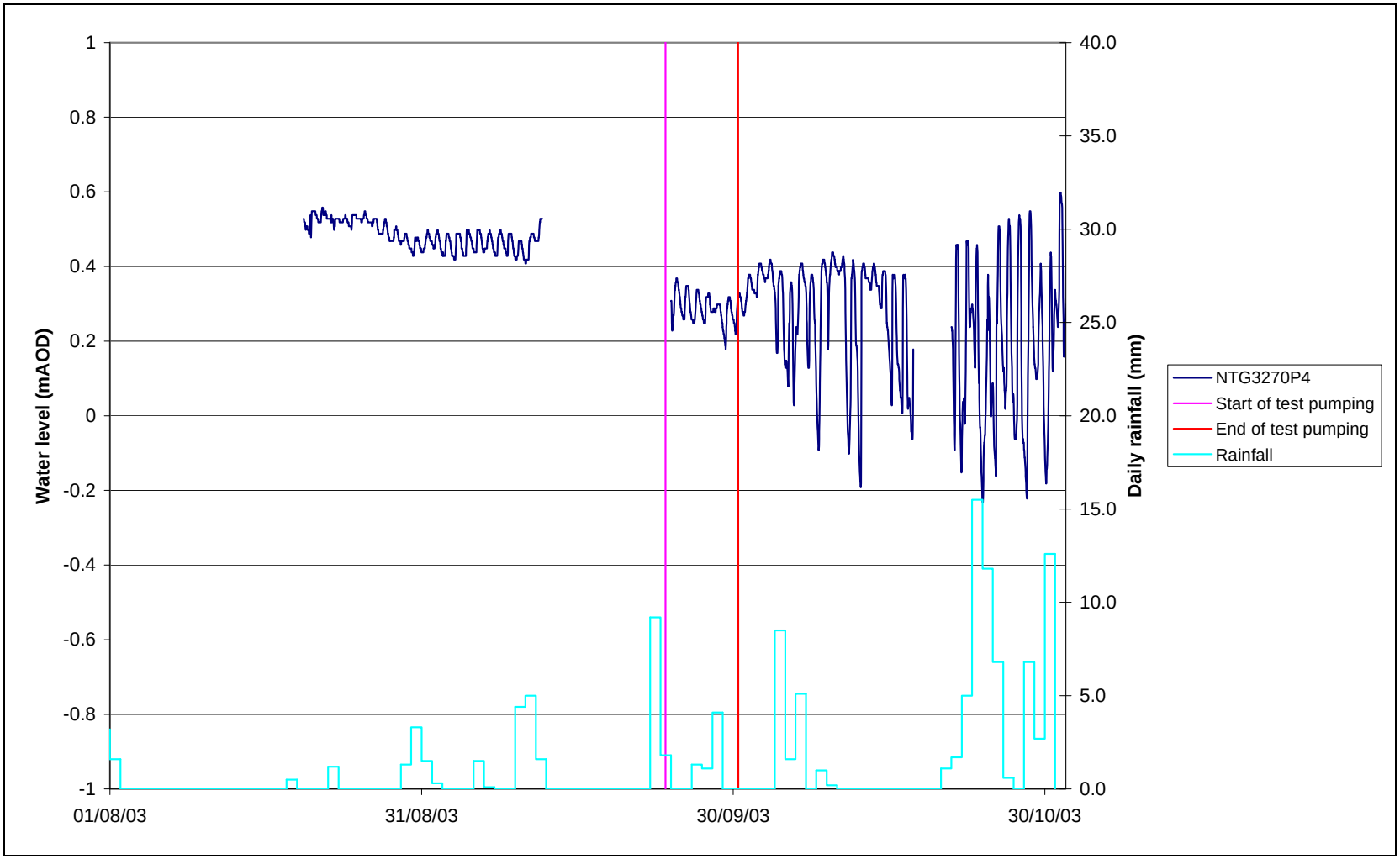


Figure E74 – Observation borehole hydrograph for NTG3270P4, with rainfall, covering the period of the 2003 pumping test (Note: the water level data were provided by AWS in mAOD, and therefore has not been amended to conform with the most recent topographic survey

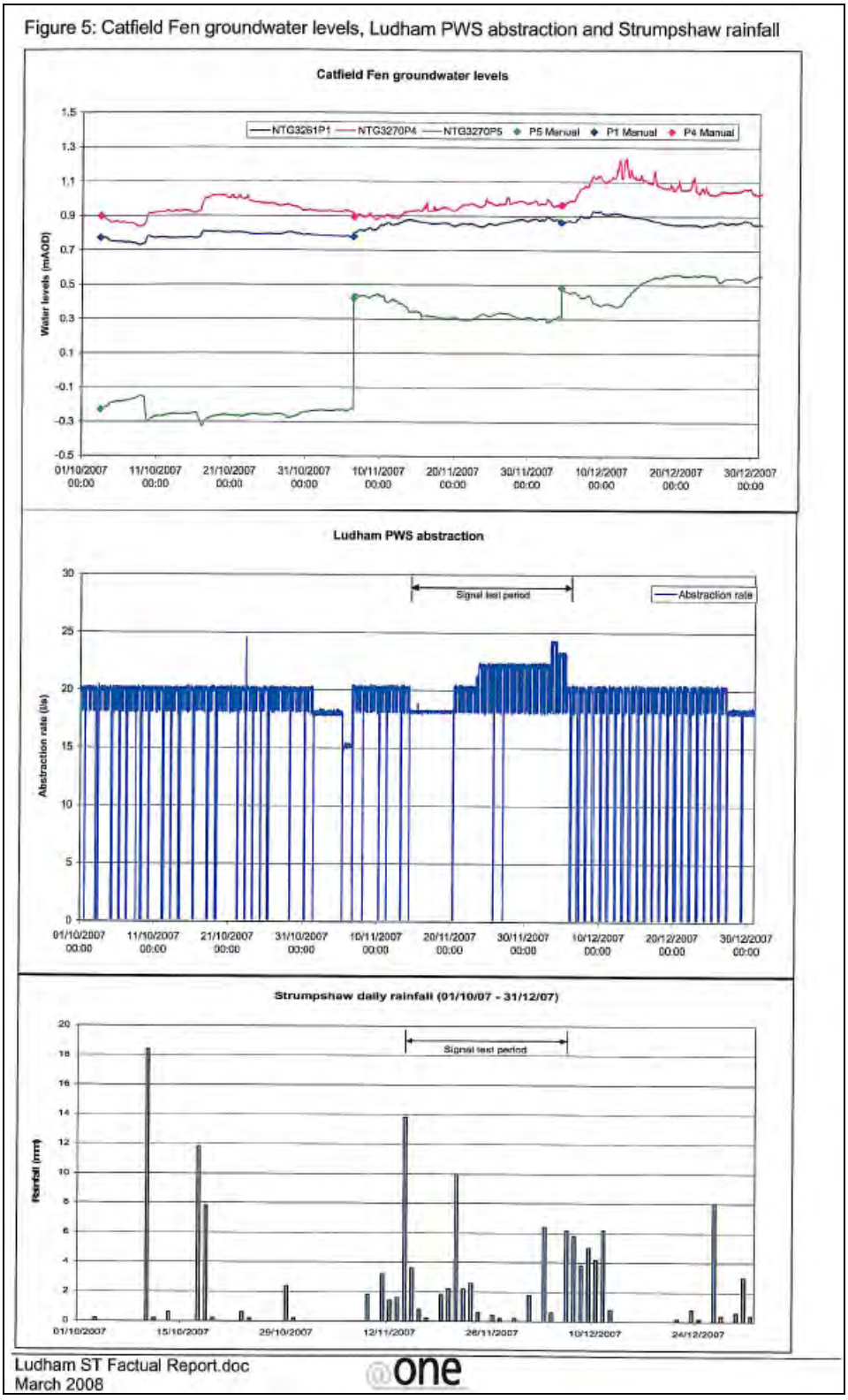


Figure E75 – Observation borehole hydrographs for NTG3270P4, NTG3270P5 & NTG3261P1 at Catfield Fen, with rainfall and abstraction, covering the period of the 2007 signal (pumping) test (from @one Alliance, 2008, Fig. 5)

Note: the water levels are based on a past topographic surveys. Recent 2011 survey data have resulted in significant changes in level, with the relationship between water levels in two boreholes (NTG3270 P4 & P5) being reversed.

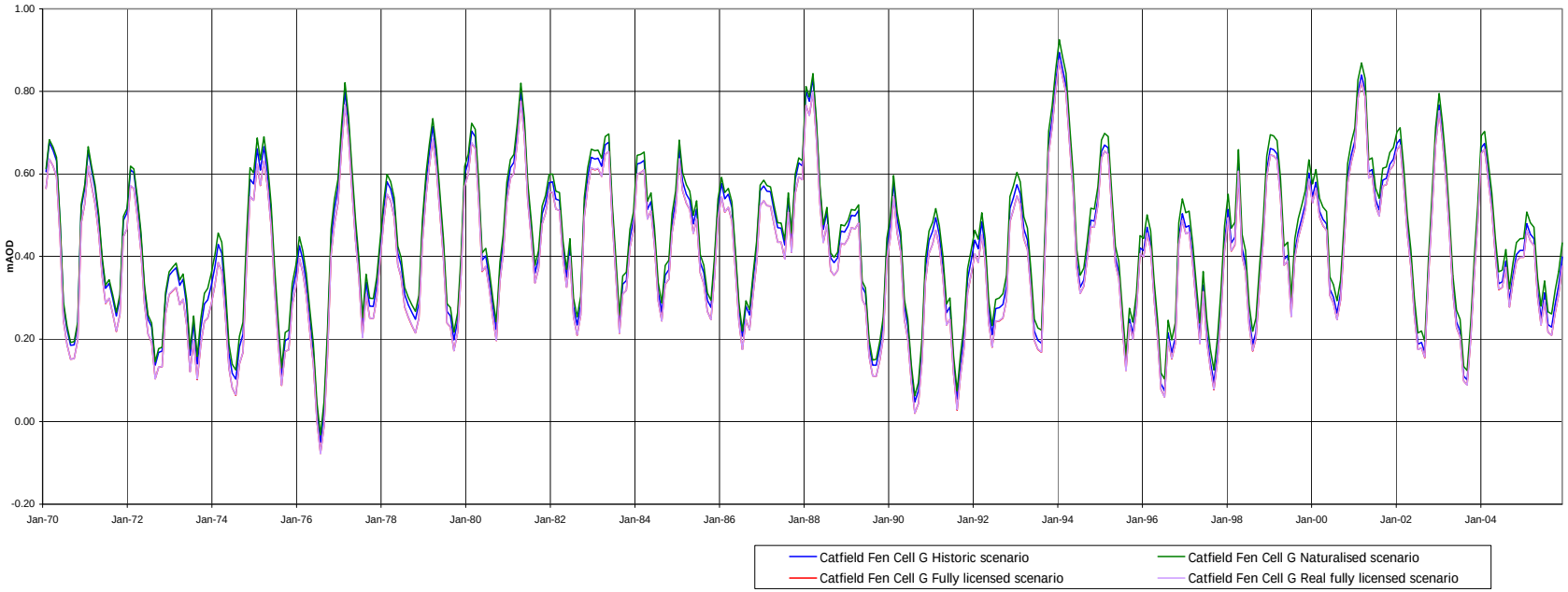


Figure E76 Modelled Groundwater Heads at Catfield Fen under different abstraction scenarios (Layer 1, row 137 column 308, cell G). The cell location covers Rose Fen and the northern half of Long Marsh (Adapted from Figure 7.14, Entec, 2009) (Note: the Ludham PWS licensed quantity used in the model is its former 680 Ml/a, not its current 512 Ml/a)

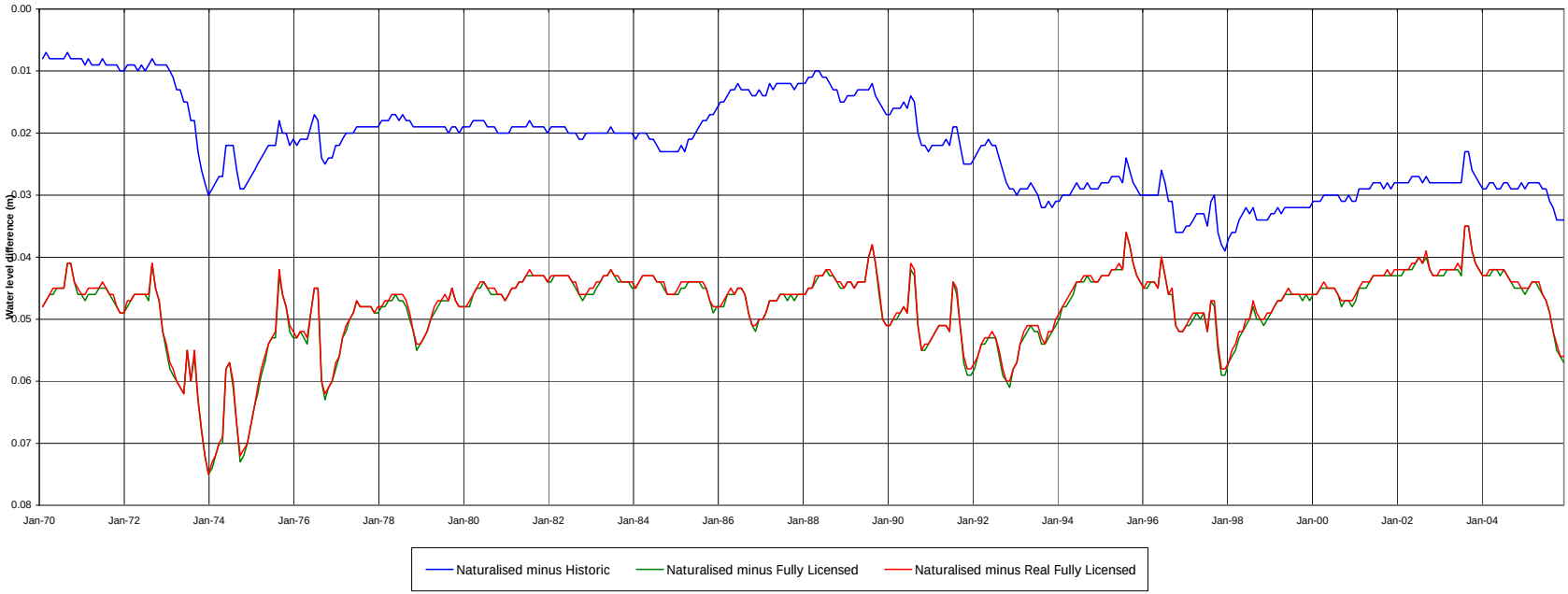


Figure E77 Modelled groundwater head differences for different abstraction scenarios in relation to modelled Naturalised Heads at Catfield Fen (Layer 1, row 137 column 308, cell G). The cell location covers Rose Fen and the northern half of Long Marsh (Based on data shown in Figure E56 Note: water level differences are shown, not water levels. Also that the Ludham PWS licensed quantity used in the model is its former 680 Ml/a, not its current 512 Ml/a)