Memo

Att.:	Participants of the TKI 'Warmteoverdracht drinkwaterleidingen'
Subject:	Results temperature measurements in Krimpen aan den IJssel 2018 and validation 2D-Soil temperature model
From:	Claudia Agudelo-Vera, Mario Castro Gama and Mirjam Blokker (KWR) and Sam van der Zwan and David Nugroho (Deltares)

Contents

1 Introduction

One of the models developed in the TKI project'*warmteoverdracht drinkwaterleidingen*' (heat transfer drinking water pipes) is the 2D-STM (2D soil temperature model). This memo describes the validation of the 2D-STM, using as boundary conditions the simulations performed with the 1D-STM (1D soil temperature model) developed by (Blokker and Pieterse-Quirijns 2013) and extended by (Agudelo-Vera, Blokker et al. 2017), based on KNMI data, thermal properties of the soil and the presence of anthropogenic sources, *Figure 1*.

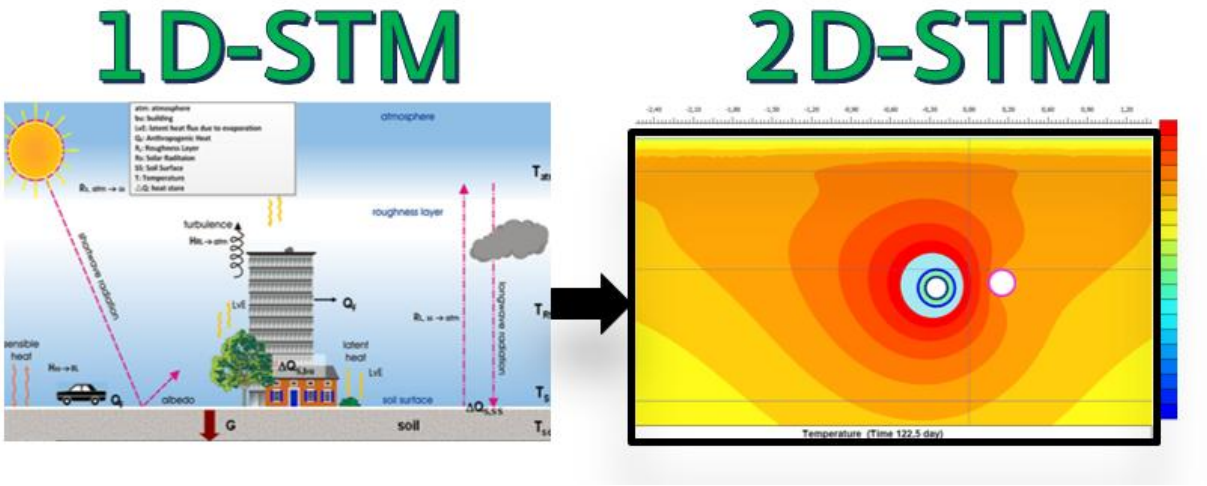

Figure 1 Schematic representation of the 1D and 2D soil temperature models. The black contour shows where the boundary conditions coming from the 1D-STM are assign.

Soil temperature measurements were conducted in the city of Krimpen aan den IJssel (The Netherlands) for the validation of the 2D-STM. The measurement period was July until October 2018. Soil temperatures were measured and registered every hour. The eight measured locations are close to flow meters of Oasen, see number of the respectively DMA in Figure 2. At these same locations there were supposed to be temperature measurements of the drinking water, but in the end this turned out to not be the case. The results of the measurement at eight locations are summarized in Chapter 2. 1D soil temperature simulations are shown in Chapter 3, validation of the 2D-STM is shown in Chapters 4 and Chapter 5 contains a final discussion and concluding remarks.

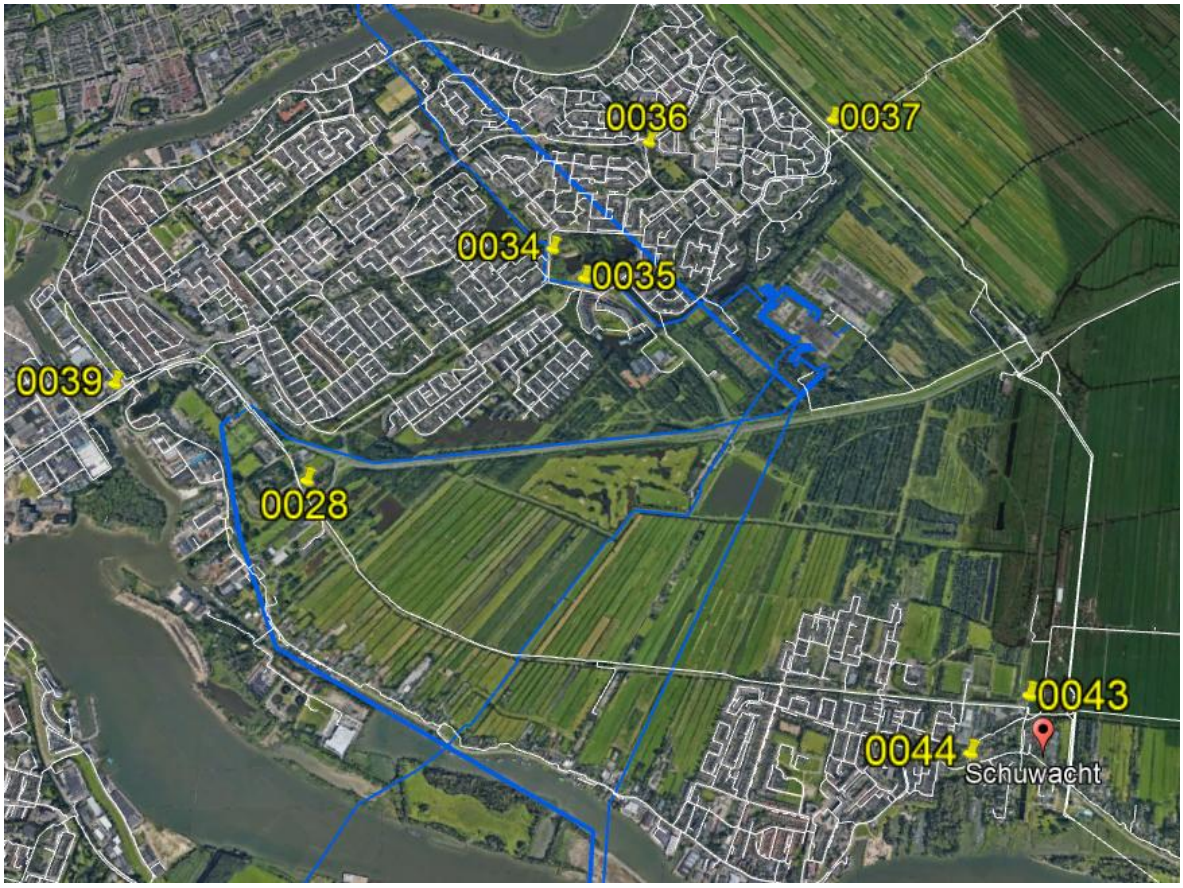

Figure 2 Overview of the eight measurement locations in Krimpen aan den IJssel and Krimpen aan de Lek. In white the drinking water pipes, in yellow the ID's of the corresponding DMAs: 0028, 0034 - 0037, 0039, 0043 and 0044), in blue the high voltage cables, the red pointer is the treatment plant Schuwacht.

2 Description of the measurements

2.1 Measurement set-up

In seven locations the measurements were performed at the depth of the drinking water pipe and at different horizontal distances, starting with a measurement close to the drinking water pipe and (if possible) 20cm, 50 cm and 100 cm from the drinking water pipe, see Figure 3. In location M2 there were horizontal and vertical measurements. There is a detail of the set-up in Chapter 4. The thermometers were taped to the pipe wall. The needles of the thermometers close to the electricity cables were protected with tape. The soil type and the depth of the ground water level are based on a visually inspection in-situ by the fitter during the installation of the thermometers.

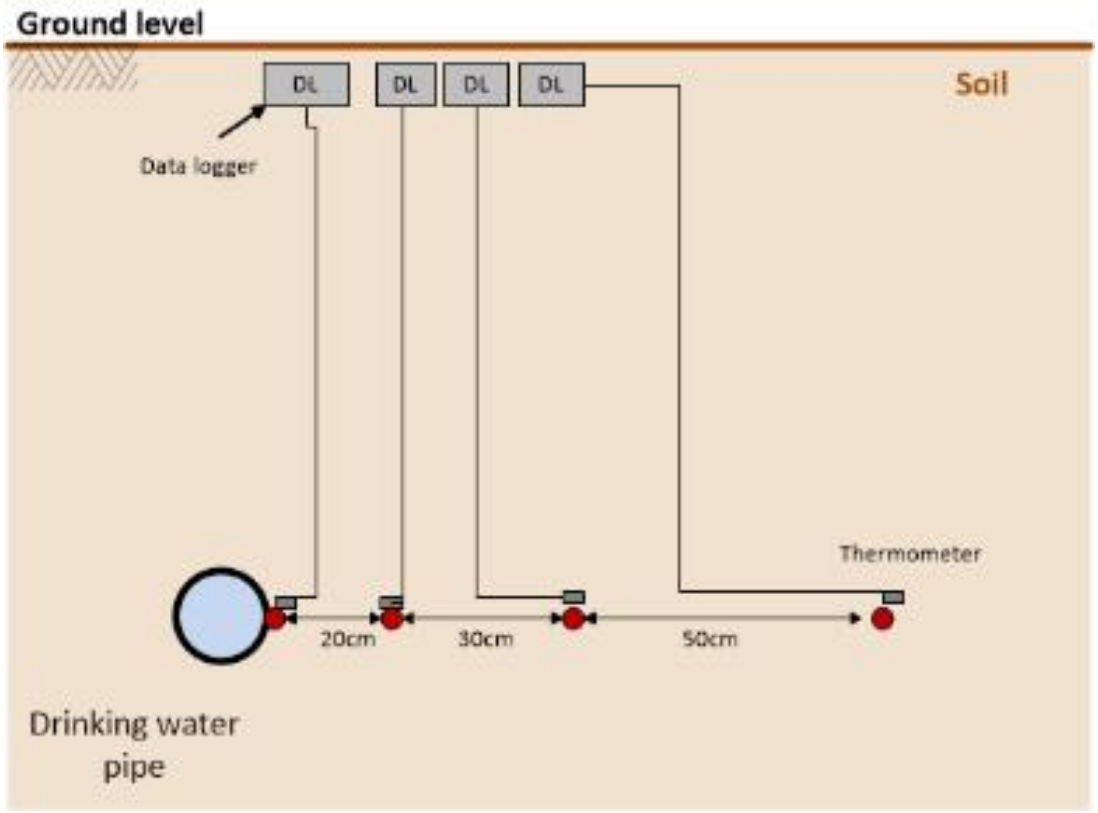

Figure 3 Schematic representation of the measurement set-up

2.2 Measurements results and discussion

Table 1 summarises the characteristics of the locations and results of the measurements. The maximum measured temperature was 26.4°C in location M3 at a depth of 0.7 m. This temperature was registered in a location close to an electricity cable with clay soil and under grass. There were two other locations with temperatures above 25 °C: location 2 & 7 at a depth 0.20 m and 0.90 m, respectively. Residence times where calculates using the hydraulic model of the area. Underground heat sources found in the locations are low voltage electric cables. At locations M3 and M4 there are high voltage electric cables at a horizontal distance of 20 and 24 meters respectively. In location M5 there is an Electrical distribution sub station

Table 1 Characteristics and maximum temperatures recorded per location (sorted per depth). In location 2 horizontal and vertical measurements were performed

id	DMA	Drinking water pipe		Soil type	GWL	Soil cover	Sun condition		Max temp. per location (°C)	
									Distance to the drinking water pipe (cm)	
		Mat Diam/wall (mm)	Depth				Sun	Shade	0	100
M1	35	PVC 160x4.7	1.3	Sand	0.7	Tiles	x	x	19.1	22.3
M2 *	36	PVC 400x9.8	1.4	Clay	0.8	Grass	x	x	16.7	18.4
			0.2 – 1.4						18.4 - 25.7	
M3	34	PVC 160x4.7	0.7	Sand /Clay	1	Tiles	x	x	20.3	26.4
M4	37	HPE 250x22.7	0.9	Peat	0.7	Grass	x		14.2	16.8
M5	39	PVC 250x7.3	1.6	Sand	> 1.6	Grass /Tiles	x		17.4	18.8
M6	28	PVC 315x9.2	0.8	Clay/ rubble	0.6	Grass	x		17.1	21.8
M7	44	HPE 160x14.6	0.9	Clay	>0.9	Grass	x		19.8	25.6
M8	43	PVC 250x7.3	1.2	Sand	1	Grass	x		22.9	23.9

*location close to a lake. In this location vertical and horizontal measurements were performed
GWL: Groundwater level. In this case it is an estimation of the fitter. This estimation was done during the installation of the thermometers. This level could have vary during the measurement period.

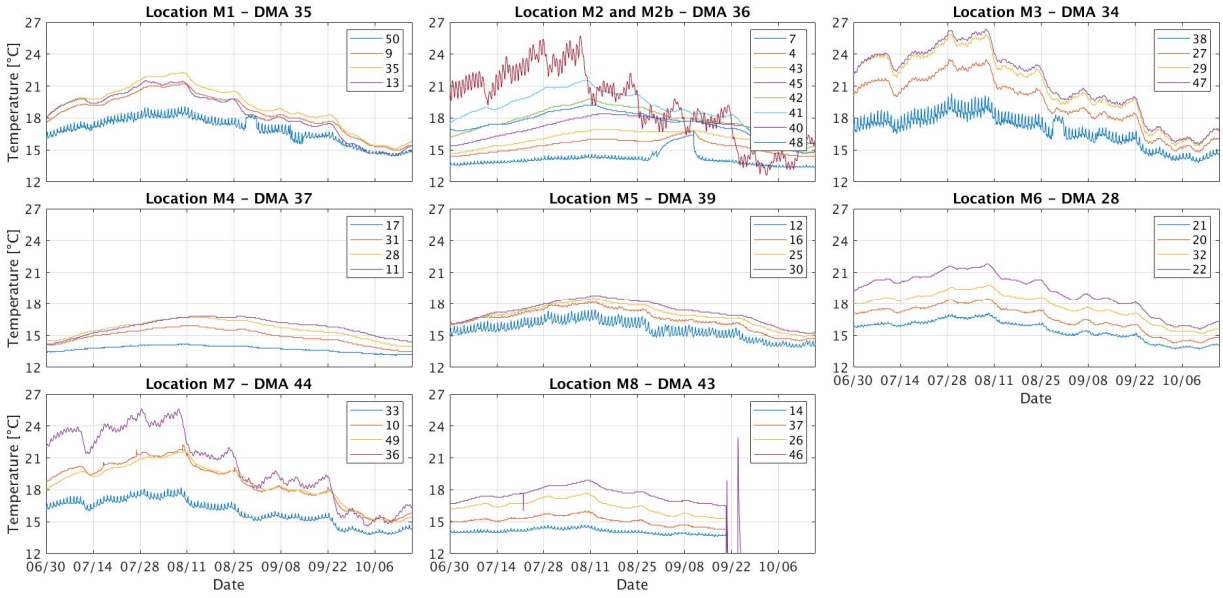

Figure 4 Temperature measurements at eight locations at the depth of the drinking water pipe. At location M2, there were horizontal and vertical measurements. The colours represent the thermometer ID.

The measurements were conducted at different depths, ground water levels, soil type and cover conditions. Therefore direct comparison of the measurements is not possible. The KNMI reported that the summer of 2018 was the hottest summer in at least 3 centuries and that the autumn of 2018 was the sunniest autumn in more than a century.
The measurements corroborate that soil temperature varies locally depending on several variables and that in an urban setting the local differences are significant. In all the locations. the thermometers close to the drinking water pipes registered the lowest temperatures and with a diurnal pattern, with a daily variation of approx. 1.5 °C for pipes above 90 cm and a small variation of 0.1°C (which is the precision of the sensors) for pipes below 90 cm, Figure 5. Temperature profiles change according to the locations and the local characteristics. There is a difference between the locations of 6 degrees in the measurements close to the drinking water pipe. Locations M2 (-1.40m), M4 (-0.9m) and M8 (-1.20m) showed a lower temperature that the rest around 14°C.

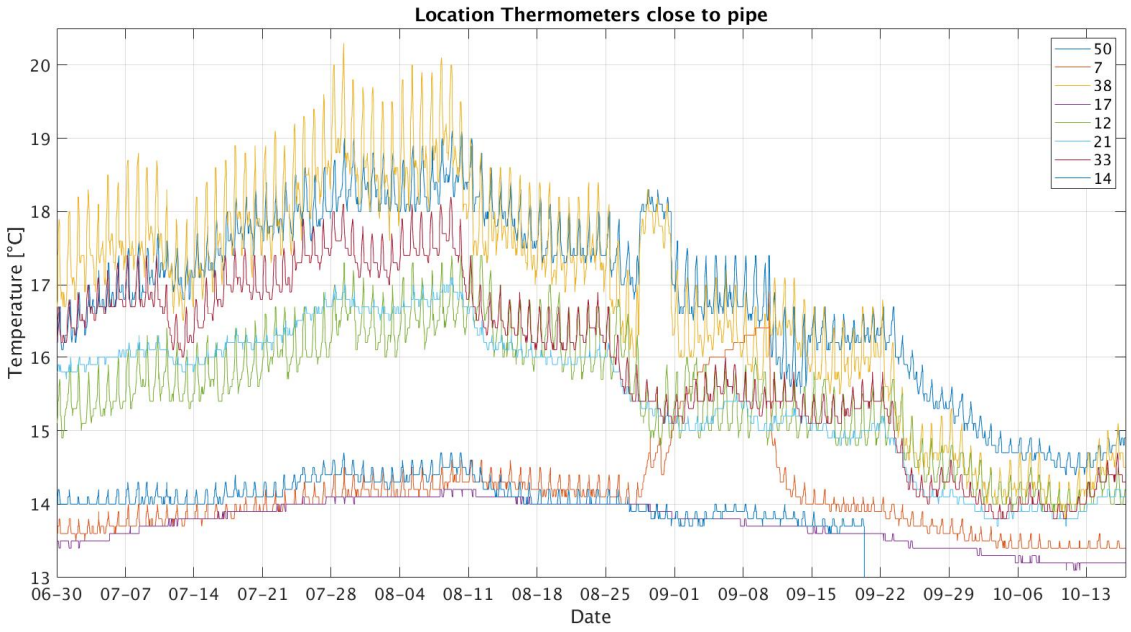

Figure 5 Temperature measurements at the pipe wall in the eight locations from M1 to M8. In the legend the number of the thermometer: 50=M1, 7=M2, 38=M3, 17=M4, 12 = M5, 21 = M6, 33 = M7 and 14=M8.

The weather conditions are visible in the temperature at the pipe wall for shallow pipes. Figure 6 shows the temperature at the pipe wall in location M3 and the respective air temperature and precipitation. The three black rectangles show the dropping in the pipe wall temperature that was caused by changes in the weather: simultaneous drop in air temperature and precipitation.

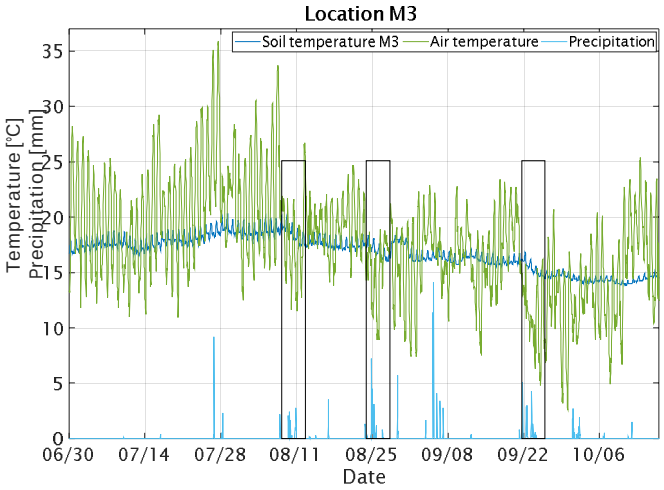

Figure 6 Temperature at the pipe wall for locations M3 and M7 and the recorded air temperature and precipitation in the closest KNMI meteorological weather station (Rotterdam).

The measurements per location showed differences up to 6°C in a range of 1 meter from the drinking water pipe. These changes in heating are due to proximity of underground heat sources and the changes in cooling are due to the flowing of colder drinking water through the pipes.

In location M1, there was a visible variation in the moisture of the soil in the area that was opened. This can be due to a leakage of the sewer system. Soil moisture affects the thermal properties and can explain the small differences of the temperature measurements at the distances 20, 50 and 100 cm.

The residence times, based on the hydraulic model, at the measured locations from Schuwacht vary from 2.5 to 27 hours. It is not possible to define a direct relationship between residence times of the water in the pipe and the temperature of the pipe wall based on the measurements alone. The reason is significant variations in depth, soil type, ground water level, etc.

Location M2 has an abrupt change starting on 28 August and finishing on 13 September, which shows an increase of almost 3 degrees on 10 September. Analysis of the flow measurements in the DMA, shows that in this period a valve was closed, which led to stagnant water (flow=0), see F*igure 7* (location 2). Changes in the flow in the network actually influences the temperature of the drinking water pipe, as show in Locations M1 and M3 which also have a flow anomaly starting in the same period but of a shorter duration, and that variations cause an anomaly in the temperature series.

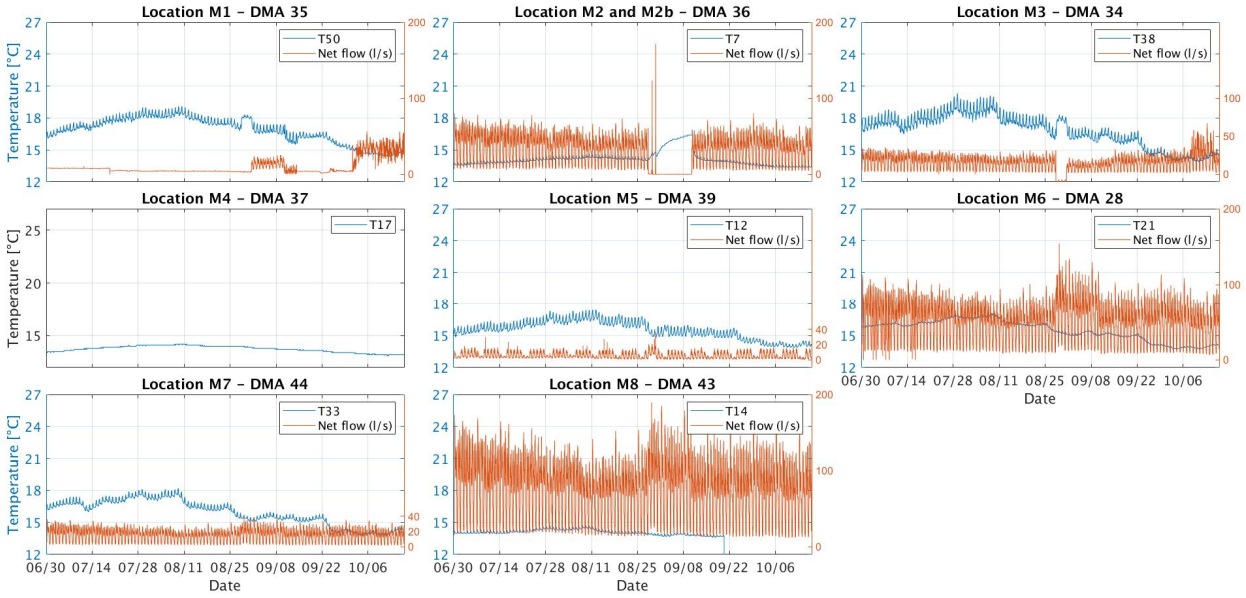

Figure 7 Temperature measurements close to the drinking water pipe (in blue) and flow measurements per location (in red), there was no data available for location M4.

3 Simulation of 1D-soil temperature profiles

The 1D-STM has been already validated (Blokker and Pieterse-Quirijns 2013, Agudelo-Vera, Blokker et al. 2017). The 1D soil temperature model can simulate the range of temperature using the variables described in Table 2. Locations with sandy soil were selected to illustrate the 1D soil temperature simulations: M1, M3 and M8. The exact thermal properties of urban soils are difficult to determine, because the grain size, compaction and moisture are not exactly known. Furthermore these properties (may) change on time and with the depth. For this reason the 1D-STM uses a bulk value that represents the thermal properties of the complete soil column. For this validation two simulations per locations were conducted: i) dry sand and ii) wet sand. In this way the uncertainty about the soil moisture is handled. Based on the photos of the locations the anthropogenic heat flux (QF) was estimated per location, Table 2.

For the monitor locations it is not possible to determine which of the measurements represents the undisturbed (not affected by drinking water temperature or other heat sources) soil temperature, due to the lack of information about the exact profile, soil type and groundwater level conditions. The lowest temperature measurement per location is affected by the heat transfer between the soil and the drinking water pipe, meanwhile the highest temperature can be the undisturbed soil temperature or affected by anthropogenic sources.

Figure 8 shows in colour the measured soil temperature and in black the simulated soil temperatures. The simulated ranges describe well the heating up of the soil and the maximum soil temperatures per location, except for the last weeks of the measured period. The 1D-STM has been calibrated for the summer conditions, that can explain with in the autumn there are larger differences. The soil temperatures close to the drinking water pipe are colder than this simulated temperatures and they cannot be simulated with this 1D-model.

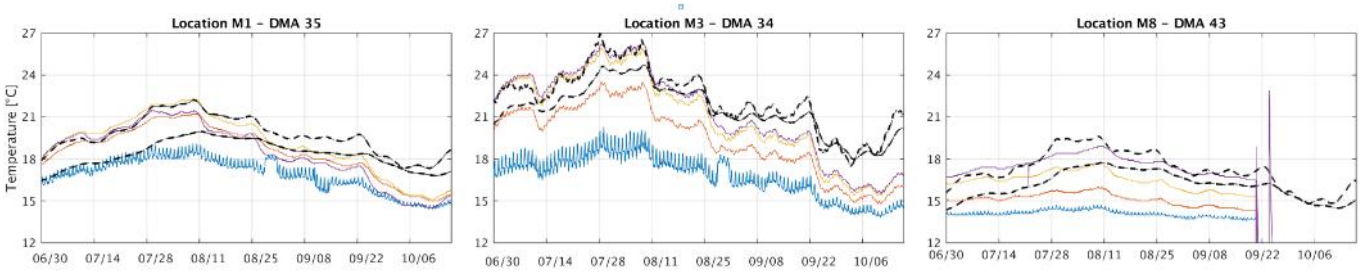

Figure 8 1D-soil temperature simulations for three locations with sandy soil. Lines in colour are the measured soil temperatures, the two black lines show the temperature range simulated with the 1D-soil temperature model for dry and wet sand. Anthropogenic heat flux adjusted per location, see Table 2.

Table 2 Variables to run the 1D-soil temperature model

	M1		M3		M8	
						
	Tiles	Tiles	Tiles	Tiles	Grass	Grass
	Medium	Medium	Medium	Medium	Medium	Medium
	Dry sand	Wet sand	Dry sand	Wet sand	Dry sand	Wet sand
λ_{soil}	1.6	1.2	1.6	1.2	1.6	1.2
ρ_{soil}	1.6	1.8	1.6	1.8	1.6	1.8
Cp_{soil}	0.8	1.2	0.8	1.2	0.8	1.2
α	1.25	0.56	1.25	0.56	1.25	0.56
z_0	0.95	0.95	0.95	0.95	0.95	0.95
Q_F	50	50	100*	100*	20	20
a1	0.8	0.8	0.8	0.8	1	1
a2	30	30	30	30	30	30
a_3^*	-50	-50	-100	-100	-20	-20
Albedo	0.12	0.12	0.12	0.12	0.19	0.19

* High voltage cable at 20m horizontal distance (depth of the cable is unknown).

4 Validation of the 2D-soil temperature model

This chapter describes the results of the validation of the 2D-soil temperature model. The validation has been done for two locations one with an electrical cable nearby (M2) and the other without any heat source in the vicinity (M3).

4.1 Location M2

4.1.1 Description of the location M2

The measurement layout on location M2 is presented in Figure 9. The underground was clay with grass as top layer. Both drinking water pipe and a low voltage electricity cable were present. The drinking water pipe is made of PVC material and has an outside diameter of 400 mm. The diameter of the electricity cable was not measured and will be assumed in the validation calculation. The center of the drinking water pipe and the electricity cable is located at 1.4 m and 1 m from the surface respectively. 8 sensors (thermometers) were placed in the underground (T7, T4, T43, T48, T40, T41, T42 and T45). T7 is located near to the drinking water pipe. T48 is located near to the electricity cable. Ground water table was found at depth of 0.8 m. Figure 10 shows the results of the measurements.

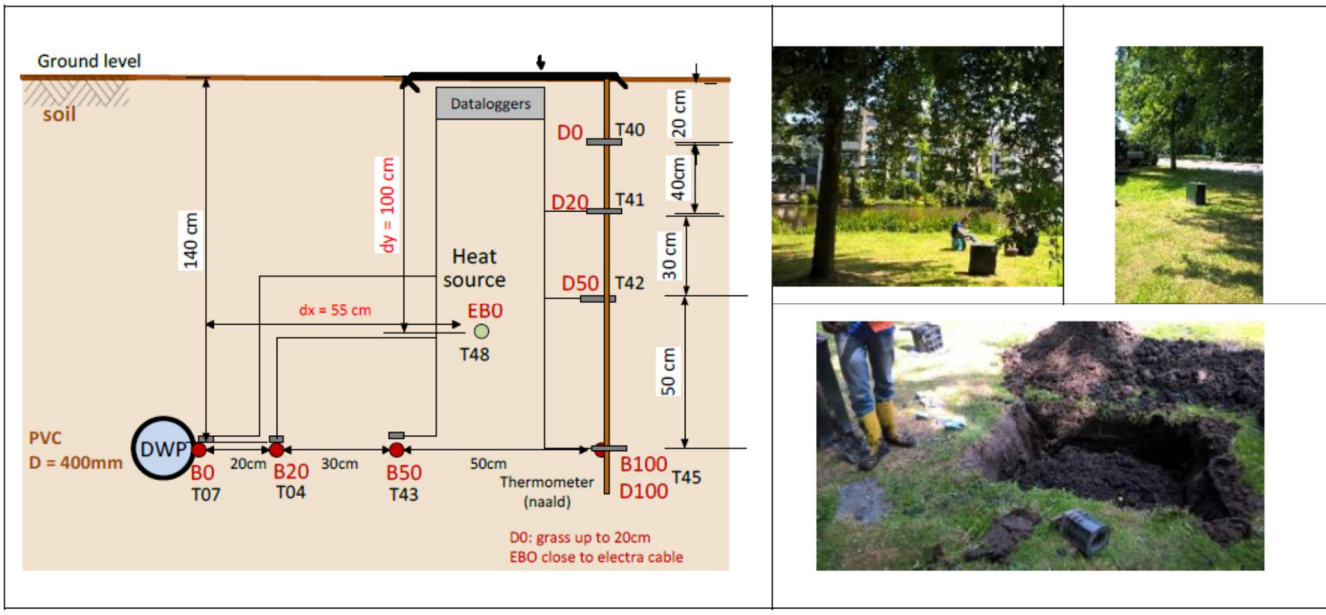

Figure 9 Measurement layout on location M2

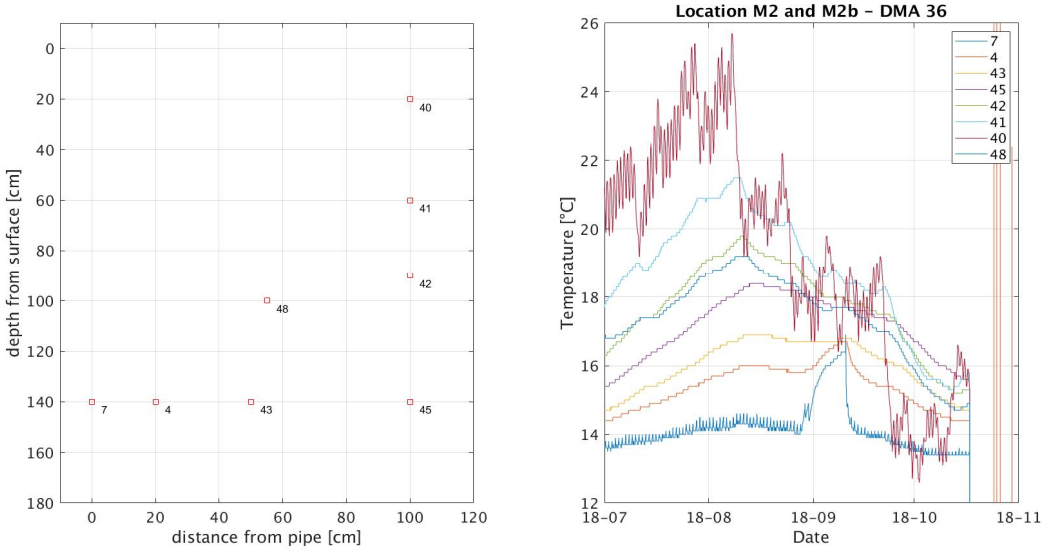

Figure 10. Measured temperature on each thermometer on location M2 between 29 June and 18 October 2018

4.1.2 Assumption and setup for validation calculation

The model is 20m wide and 10 m deep, which is the same as used in sensitivity analysis (11201825-000-HYE-0004-m-WP2) . Figure 11 shows an overview of part of the model showing all sensor locations.

The following assumptions were used for the validation calculation:

- Surface temperature of GMVz scenario for a situation of Rotterdam in 2018 and clay underground (11201825-000-HYE-0004-m-WP2_def1). The gras with clay boundary temperature was not available and the properties of clay almost match those of wet sand.
- PVC pipe with an outside diameter of 400 mm and wall thickness of 11.7 mm.
- Initial temperature uses the temperature profile (with depth) on 29 June.
- The outside diameter of the electricity cable was assumed to be 80 mm.
- The measured temperature of T7 were used to estimate the temperature of drinking water.
- The measured temperature of T48 was applied at the electricity pipe, since no information was available on the currents running through this line.
- Temperature boundaries follow 11201825-000-HYE-0004-m-WP2_def1.

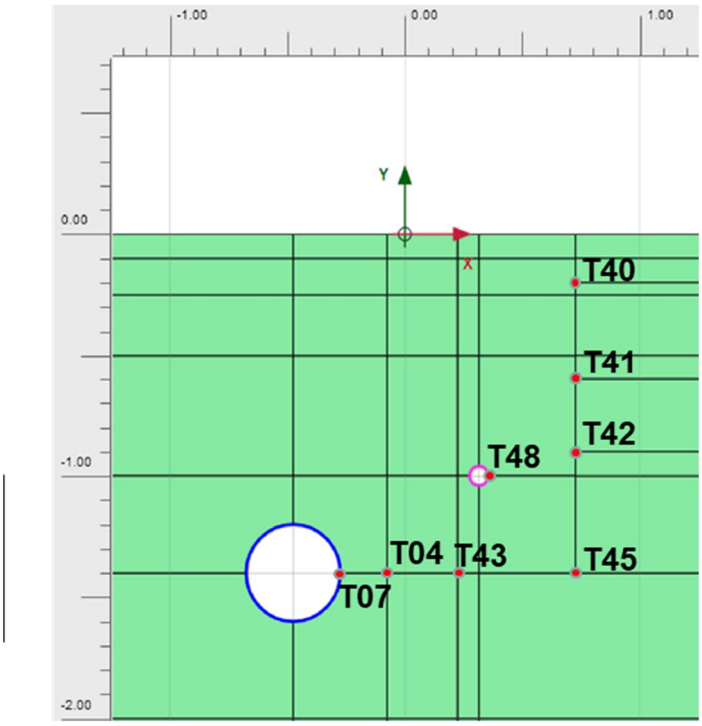

Figure 11 Model used for the validation of measurement on location M2

4.1.3 Comparison between measured and calculated temperatures

The difference between measured and calculated temperatures is presented in Figure 12 (day 0 is 29 June 2018). T07 and T48 are used as boundary condition. It can be observed that most of the calculated temperatures are reasonably in agreement with the measured ones. The overall trend is the same. However, the measurements at sensor T40 show less fluctuation then shown with the simulations. The same holds for sensor T41, which is deeper, and the fluctuations are more damped. The simulation show more fluctuation which show that more heat is transported into the subsoil and the temperature will thus be higher as observed for the measurement points. It is difficult to assess why the model shows a larger heat transport into the subsoil. This might come from different soil properties or form a wrong influx at the top.

Concluding the overall trend is the same for the measurements and the simulations, this shows that the physics are correctly taken into account in the model. No exact match has been found, but this can be caused by boundary conditions or heterogeneity of the soil which are not exactly know. Therefore, it is not possible to make a further step in the validation for this location.

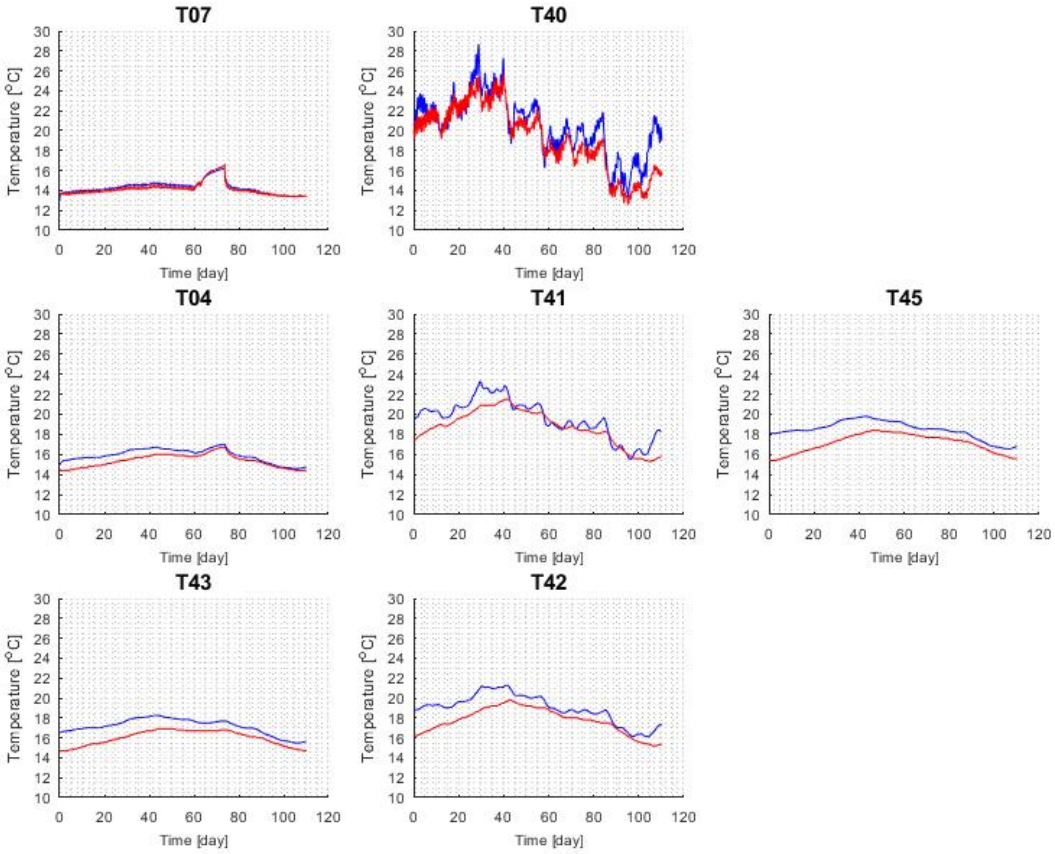

Figure 12 Measured and calculated temperatures at the different measurement locations (bottom temperature boundary at 10 m depth)

4.2 Location M3

4.2.1 Description of the location M3

The measurement layout on location M3 is presented in Figure 13. The underground was mixed of clay and sand with tile as top layer. Only drinking water pipe was present. The drinking water pipe is made of PVC material and has an outside diameter of 160 mm. The center of the drinking water pipe is located at 0.7 m from the surface. Four sensors (thermometers) were placed in the underground (T38, T27, T29 and T47). T38 is located near to the drinking water pipe. Ground water table was found at depth of 1 m. The measurement results are shown in Figure 14.

Figure 13 Measurement layout on location M3

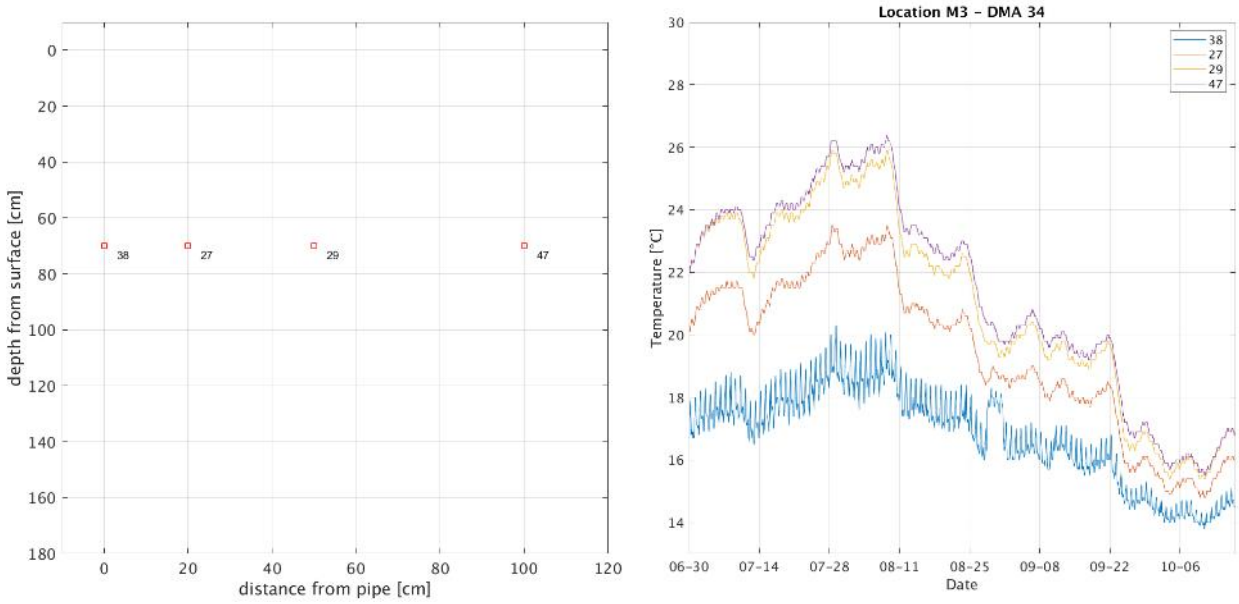

Figure 14 Measured temperature on each thermometer on location M3 between 29 June and 18 October 2018

4.2.2 Assumption for validation calculation

The model is 16 m wide and 9 m deep (see Figure 3). The following assumptions were used for the validation calculation:

- Surface temperature of TMZK scenario for a situation of Rotterdam in 2018 and sand-clay underground (WP2).
- PVC pipe with an outside diameter of 160 mm.
- Initial temperature uses the temperature profile (with depth) on 29 June.
- The measured temperature of T38 was applied at the drinking water pipe.
- Temperature boundaries follow WP2.

Figure 15 shows part of the model used for the validation.

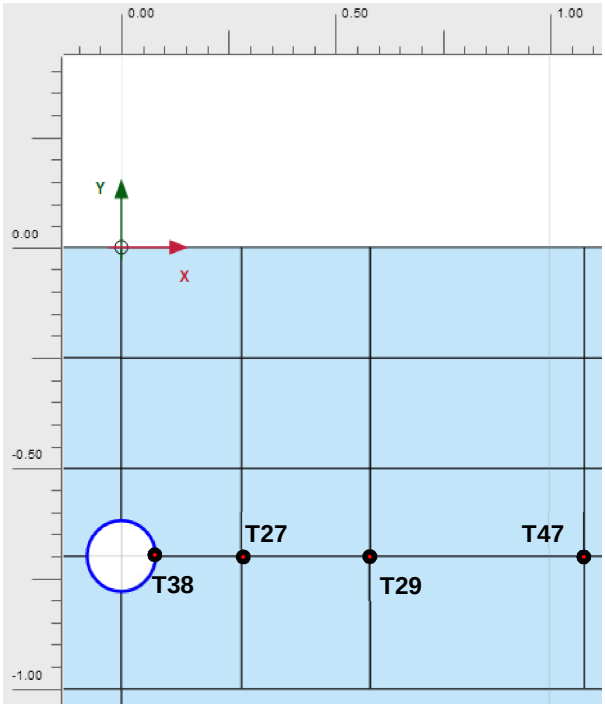

Figure 15 Part of the model used for the validation of measurement on location M3

Comparison between measured and calculated temperatures

Figure 16 show a comparison between measured and calculated temperatures (day 0 is 29 June 2018). T38 is used a boundary condition. It can be observed that the calculated temperatures from day 0 to 40 are reasonably in agreement with the measured one. On day 60 the calculated temperatures start to deviate and are larger than the measured ones. This has to do with the top boundary condition which also shows a deviation from the measurements from day 40, see Figure 8.

Concluding the 2D soil temperature model captures the physics correctly, however the results are much influenced by the boundary condition.

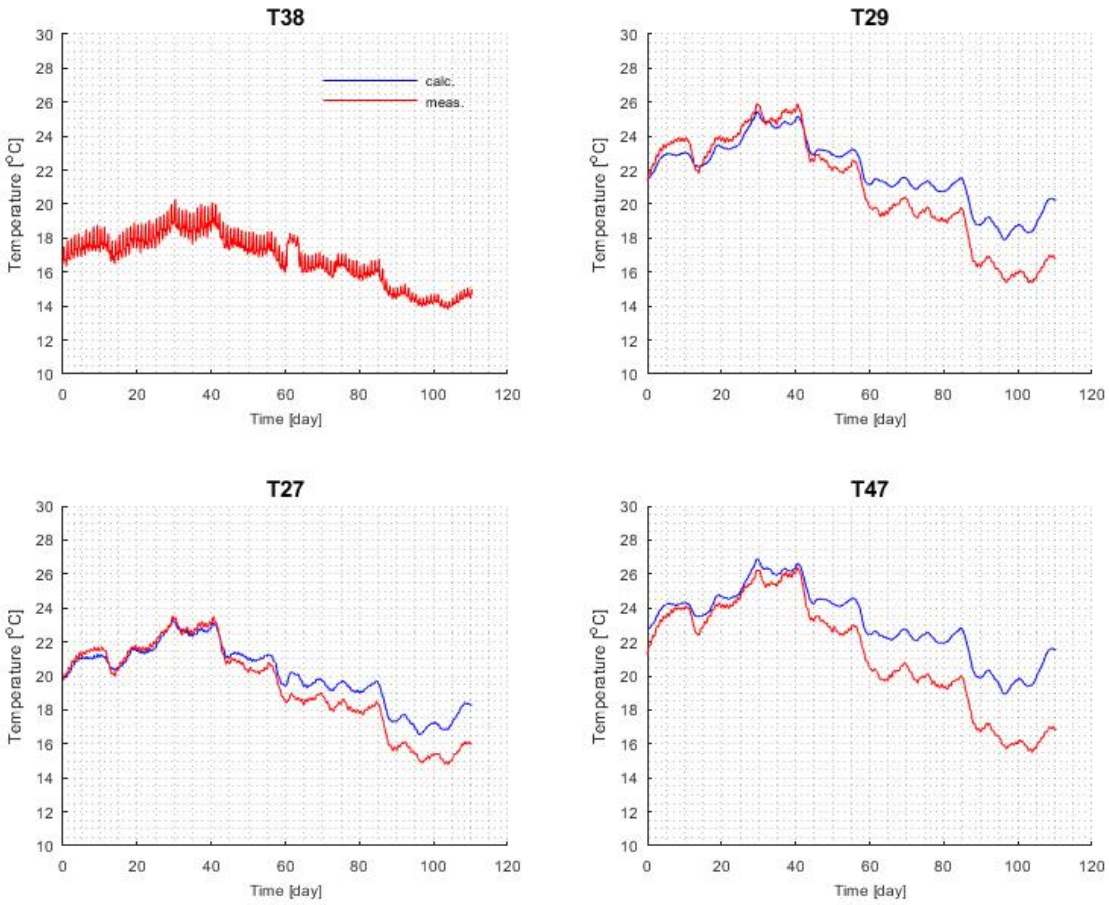

Figure 16 Measured and calculated temperatures at the different measurement locations (bottom temperature boundary at 10 m depth)

5 Final discussion and concluding remarks

The measurements corroborate that soil temperature varies locally depending on several variables and that in an urban setting the local differences are significant. In all the locations the thermometers close to the drinking water pipes registered the lowest temperatures.

For the monitor locations it is not possible to determine which of the measurements represents the undisturbed (not affected by drinking water temperature or other heat sources) soil temperature, due to the lack of information about the exact profile, soil type and groundwater level conditions. The lowest temperature measurement per location is affected by the heat transfer between the soil and the drinking water pipe, meanwhile the highest temperature can be the undisturbed soil temperature or affected by anthropogenic sources.

Measurements under controlled conditions, such as the installation in Sheffield or locations where different factors can be monitored together with additional information such as drinking water temperature will allow more accurate modelling and further validation of the models.

Simulating soil temperatures allows to describe several scenarios and evaluate the effect of different parameters. The 2D soil temperature model captures the physics correctly, however the results are much influenced by the boundary condition.

6 References

Agudelo-Vera, C., M. Blokker, H. De Kater and R. Lafort (2017). "Identifying (subsurface) anthropogenic heat sources that influence temperature in the drinking water distribution system." DWES 10: 83-91.

Blokker, E. J. M. and I. Pieterse-Quirijns (2013). "Modeling temperature in the drinking water distribution system." AWWA 105: E19-E28.

Nugroho D., "Summary of the results of 2-dimensional heat transfer analysis", Deltares 2018

7 Annex

7.1 Detailed measurements per location

Location M1

Large differences in the soil type were found in location M1. The soil of the figure 1d also had a smell to organic matter, this could be explained by a leak of the sewer system.

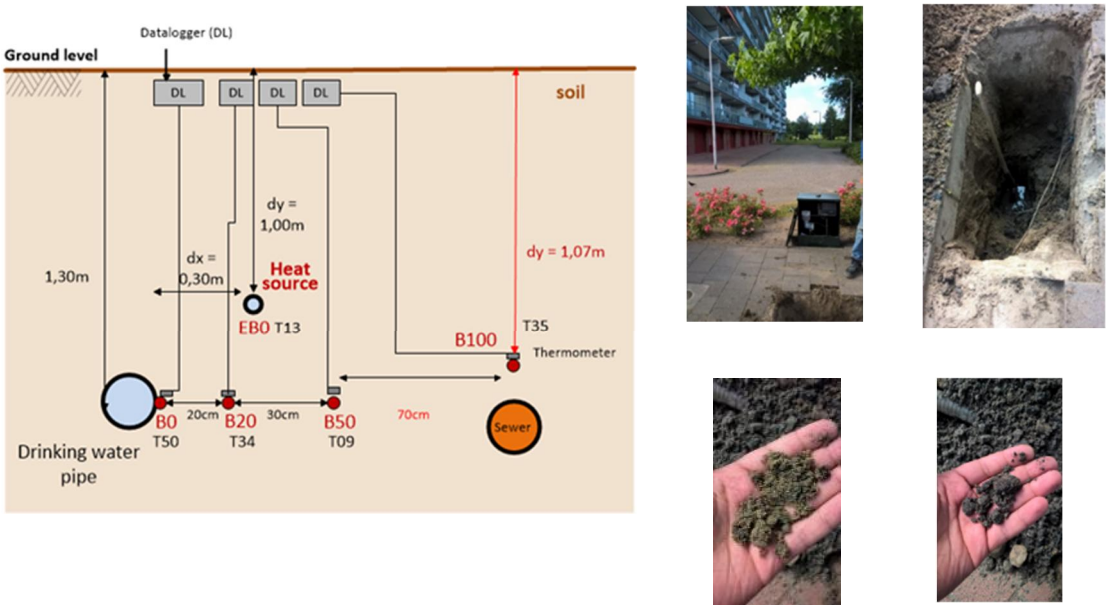

Figure 17 Schematic representation of the measurement set-up in location M1and photos during the installation of the thermometers

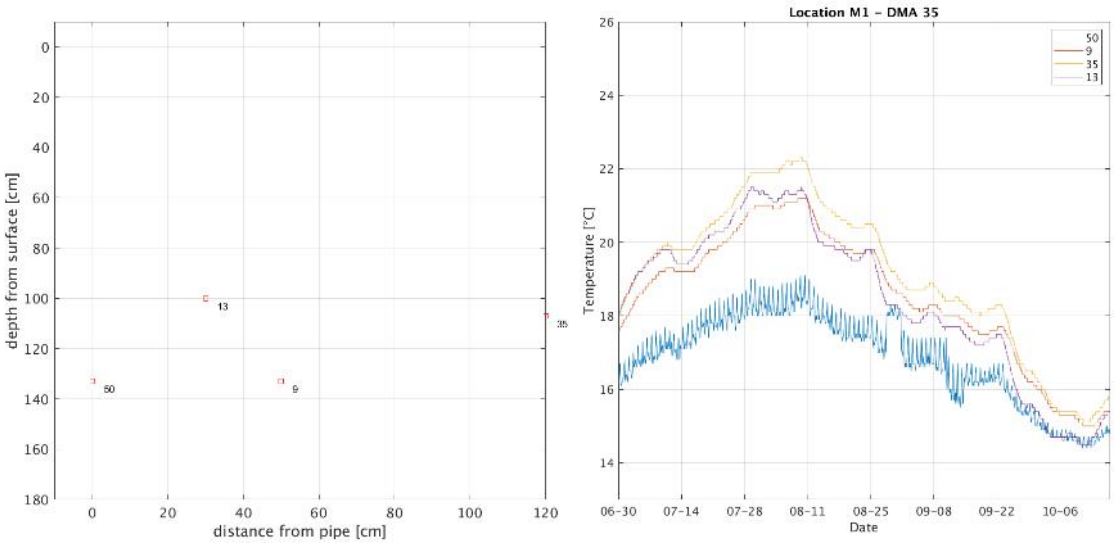

Figure 18 Temperature measurements in location M1

Location M4

Figure 19 Surroundings and detail of the measurement set-up in location M4

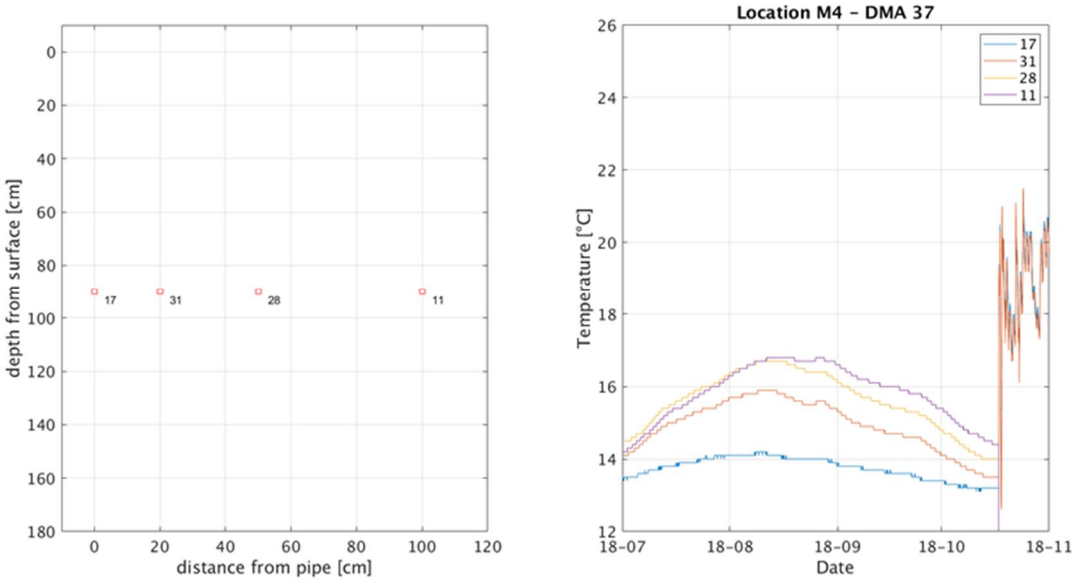

Figure 20 Temperature measurements in location M4

Location M5

Figure 21 Surroundings of the measurement set-up in location M5

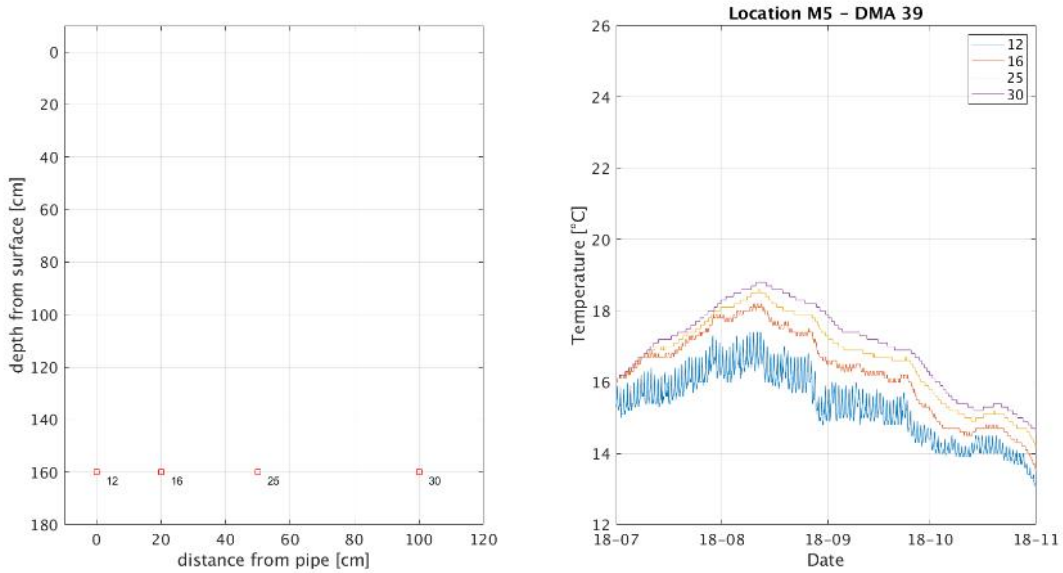

Figure 22 Temperature measurements in location M5

Location M6

Figure 23 Surroundings of the temperature measurements in location M6

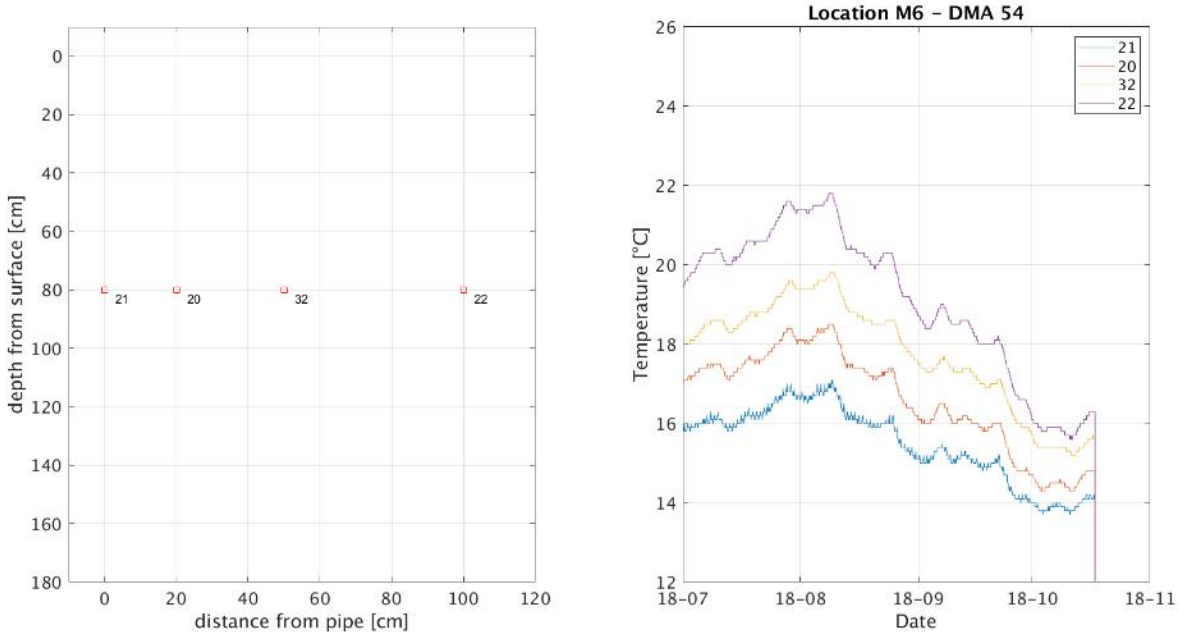

Figure 26 Temperature measurements in location M6

Location M7

Figure 27 Detail of the temperature measurements in location M7

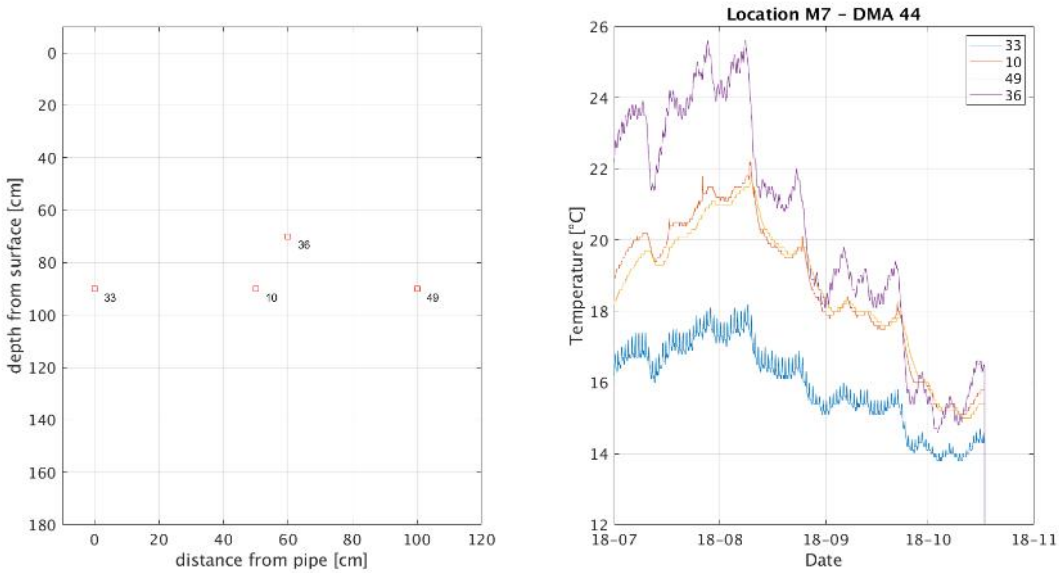

Figure 28 Temperature measurements in location M7

Location M8

Figure 29 Detail of the temperature measurements in location M8

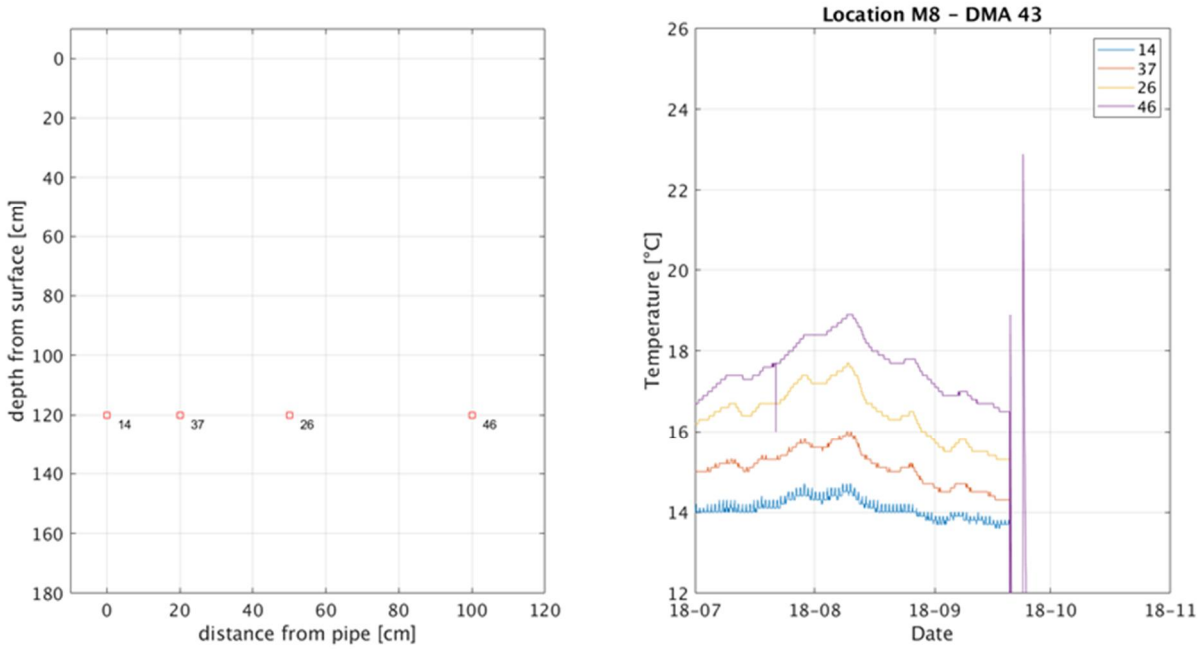

Figure 30 Temperature measurements in location M8

7.2 Forms filled in by the fitters during the installation of the thermometers

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**27-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☒ **M1** ☐ **M2** ☐ **M2b** ☐ **M3** ☐ **M4** ☐ **M5** ☐ **M6** ☐ **M7** ☐ **M8**				
Adres	Krimpen ad Ijssel Vijverlaan				
Locatie (x, y, z) uit GPS metingen	DMA 35				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 1,33 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)	T50	T34	T09	T35	30 cm boven en 1m diepte EBO = T13
Omgevingsdata					
Grondsoort	☒ Sand ☐ Clay ☐ anders:____				
Meetpunt in grondwater (tijdens installatie)	☐ Nee ☐ Wisselend ☐ Ja Inschatting diepte grondwater _0.70__ m				
Type verharding / bestrating	☐ Grass ☒ Tegels ☐ Bomen / struiken				
Locatie in de	☒ Zon ☒ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders: B100 is boven en riol, diepte 1.07 Pipe HPE 160mm Alle thermometers met naald horizontaal links van waterleiding Fietspad op de andere kant van de waterleiding (rechts)				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Mario van KWR heeft de foto's voor dit locatie				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**27-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☒ **M2** ☒ **M2b** ☐ **M3** ☐ **M4** ☐ **M5** ☐ **M6** ☐ **M7** ☐ **M8**				
Adres	Krimpen ad Ijssel Vijverlaan				
Locatie (x, y, z) uit GPS metingen	Moderato DMA 36				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen nl. 1,40 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	20 cm	60 cm	90 cm	140 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)	40	41	42	45	
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Anders nl __ m. Electra Dx = 55cm Dy = 100cm
Thermometer-id (zie nummer in het doos)	07	04	43	45	48
Omgevingsdata					
Grondsoort	☐ Sand ☒ Clay ☐ anders:____				
Meetpunt in grondwater (tijdens installatie)	☐ Nee ☐ Wisselend ☐ Ja Inschatting diepte grondwater _0.80__ m				
Type verharding / bestrating	☒ Grass ☐ Tegels ☐ Bomen / struiken				
Locatie in de	☒ Zon ☒ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders: Locatie naast een vijver				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Mario van KWR heeft de foto's van dit gebied				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**28-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☐ **M2** ☐ **M2b** ☒ **M3** ☐ **M4** ☐ **M5** ☐ **M6** ☐ **M7** ☐ **M8**				
Adres	Heemlaan 18 Krimpen ad Ijssel				
Locatie (x, y, z) uit GPS metingen	DMA 34 pvc 160				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 0,70 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)	38	27	29	47	
Omgevingsdata					
Grondsoort	☒ Sand ☒ Clay ☐ anders:____				
Meetpunt in grondwater (tijdens installatie)	☒ Nee ☐ Wisselend ☐ Ja Inschatting diepte grondwater 1,0 m				
Type verharding / bestrating	☐ Grass ☒ Tegels ☐ Bomen / struiken				
Locatie in de	☒ Zon ☒ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders:				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Foto's genomen door Johan Verspuij				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**28-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☐ **M2** ☐ **M2b** ☐ **M3** ☒ **M4** ☐ **M5** ☐ **M6** ☐ **M7** ☐ **M8**				
Adres	Breekade 19 Krimpen ad Ijssel				
Locatie (x, y, z) uit GPS metingen	DMA 37 HPE 315				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 0,90 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)	17	31	28	11	
Omgevingsdata					
Grondsoort	☐ Sand ☐ Clay ☒ anders:Veen				
Meetpunt in grondwater (tijdens installatie)	☐ Nee ☐ Wisselend ☒ Ja Inschatting diepte grondwater 0,70 m				
Type verharding / bestrating	☒ Grass ☐ Tegels ☐ Bomen / struiken				
Locatie in de	☒ Zon ☐ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders:				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Foto ' s genomen door Johan Verspuij				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**28-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☐ **M2** ☐ **M2b** ☐ **M3** ☐ **M4** ☒ **M5** ☐ **M6** ☐ **M7** ☐ **M8**				
Adres	Industrieweg Krimpen ad Ijssel				
Locatie (x, y, z) uit GPS metingen	DMA 39 PVC 250				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 1,60 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)	12	16	25	30	
Omgevingsdata					
Grondsoort	☒ Sand ☐ Clay ☐ anders:				
Meetpunt in grondwater (tijdens installatie)	☒ Nee ☐ Wisselend ☐ Ja Inschatting diepte grondwater ??? m				
Type verharding / bestrating	☒ Grass ☒ Tegels ☐ Bomen / struiken				
Locatie in de	☒ Zon ☐ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders:				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Foto ' s genomen door Johan Verspuij				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**28-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☐ **M2** ☐ **M2b** ☐ **M3** ☐ **M4** ☐ **M5** ☒ **M6** ☐ **M7** ☐ **M8**				
Adres	Tiendweg 54 Krimpen ad Ijssel				
Locatie (x, y, z) uit GPS metingen	DMA 28 HPE 315				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 0,80 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)	21	20	32	22	
Omgevingsdata					
Grondsoort	☐ Sand ☐ Clay ☒ anders: grond / puin				
Meetpunt in grondwater (tijdens installatie)	☐ Nee ☐ Wisselend ☒ Ja Inschatting diepte grondwater 0,60 m				
Type verharding / bestrating	☒ Grass ☐ Tegels ☐ Bomen / struiken				
Locatie in de	☒ Zon ☐ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders:				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Foto's genomen door Johan Verspuij				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**29-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☐ **M2** ☐ **M2b** ☐ **M3** ☐ **M4** ☐ **M5** ☐ **M6** ☒ **M7** ☐ **M8**				
Adres	Ooster Lekdijk Krimpen aan de Lek				
Locatie (x, y, z) uit GPS metingen	DMA 44 HPE 160				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 0,90 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl ___ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	Op electrakabel 0,70 diep, 0,60 vanaf hoofdleiding
Thermometer-id (zie nummer in het doos)	33	23	10	49	36
Omgevingsdata					
Grondsoort	☐ Sand ☒ Clay ☐ anders:				
Meetpunt in grondwater (tijdens installatie)	☒ Nee ☐ Wisselend ☐ Ja Inschatting diepte grondwater ??? m				
Type verharding / bestrating	☒ Grass ☐ Tegels ☐ Bomen / struiken En Asfalt				
Locatie in de	☒ Zon ☐ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders:				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Foto's genomen door Johan Verspuij				

Per locatie wordt het volgende formulier ingevuld:

Items die geregistreerd (moeten) worden bij het plaatsing van de temperatuursensoren

Gegevens	Opmerkingen / Aanvulling				
Naam Drinkwaterbedrijf	Oasen				
Datum installatie	**29-6-2018**				
Locatie (Zie Error! Reference source not found. **– Overzicht locaties)**	☐ **M1** ☐ **M2** ☐ **M2b** ☐ **M3** ☐ **M4** ☐ **M5** ☐ **M6** ☐ **M7** ☒ **M8**				
Adres	Breekade 37 Krimpen aan de Lek				
Locatie (x, y, z) uit GPS metingen	DMA 43 HPE 200				
Diepte van de metingen t.o.v. maaiveld	Diepte van leidingen of warmte leiding of elektriciteitskabel nl. 1,20 m				
Indien meerder dieptes (zie beneden figuur 1). Diepte van de metingen t.o.v. maaiveld	0 cm	20 cm	50 cm	100 cm	Anders nl __ m.
Thermometer-id (zie nummer in het doos)					
Horizontale afstand naar de waterleiding of warmtebron (zie plaatje beneden) (zie beneden figuur 2).	0 cm	20 cm	50 cm	100 cm	
Thermometer-id (zie nummer in het doos)	14	37	26	46	
Omgevingsdata					
Grondsoort	☒ Sand ☐ Clay ☐ anders:				
Meetpunt in grondwater (tijdens installatie)	☐ Nee ☐ Wisselend ☒ Ja Inschatting diepte grondwater 1,0 m				
Type verharding / bestrating	☒ Grass ☐ Tegels ☐ Bomen / struiken En puin				
Locatie in de	☒ Zon ☐ Schaduw ☐ Onbekend				
Bijzonderheden tijdens installatie	☐ Werkzaamheden aan de straat ☐ Aanpassingen van gegevens coördinaten ☐ Anders:				
maak foto's van de omgeving: oost, west, noord, zuid, opengegraven grond en afgedichte locatie	Foto's genomen door Johan Verspuij				