PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.2

IMPLEMENTATION OF BEST PRACTICES FOR WATER PROTECTION IN PILOT ACTIONS

D.T2.2.2 PARTNER-SPECIFIC PILOT ACTION DOCUMENTATIONS

PILOT ACTION: PA2.3 Tisza Catchment area

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1. Introduction

Best management practices (hereinafter BMPs) for drinking water protection and management derived from T1 were reviewed and relevant BMPs were selected for particular pilot action. Implementation status of BMPs was verified in Pilot Actions (T2); in case of lacks identified, possibilities of improvement and implementation were also assessed. Drinking water protection and management and best practices are strategically implemented in the pilot actions, in order to achieve a function-oriented land-use based spatial management for water protection at the operational level. Measures and actions were analysed and proposed concerning mitigation of extremes and achieving a sustainable drinking water level. PROLINE-CE pilot actions reflect the broad range of possible conflicts regarding drinking water protection, such as: forest ecosystem service function; land-use planning conflicts; flooding issues; impact of climate change and land-use changes; demonstration of effectiveness of measures including ecosystem services and economic efficiency.

Review of main land use conflicts and BMPs on Pilot Action level has already been done in Pilot Action BMPs reports, which were a basis for *D.T2.1.2 Transnational case review of best management practices in pilot actions*. Description of natural characteristics of Pilot Site is presented in *D.T.1.4 Descriptive documentation of pilot actions and related issues*.

Activities within Pilot Action were done according to set-up which was described in *D.T2.1.5 Set-up report about adaptation of the transnational concept to pilot action level*.

The Deliverable *D.T2.2.2 Partner-specific pilot action documentations* presents final Pilot Action report regarding the management actions examined in the Pilot Action, description of conducted activities and identified solutions for case-specific adaptations of management concepts. This report presents final work report regarding the implementation of best management practices for drinking water protection in pilot action PA2.3 Tisza Catchment area.

2. Testing of BMPs in Pilot Action

2.1. Objective(s) of Pilot Action

The aim of testing the identified BMPs in Pilot Action 2.3 Tisza Catchment is to provide a better interaction between drinking water supply systems and land use in the pilot area.

The main source of drinking water on the pilot site is groundwater from porous aquifers. Most of these groundwater resources are not vulnerable to surface contaminants. There are also six perspective drinking water resources (of which four are bank-filtered resources), with 222 million m^3/day capacity.

The surface drinking water abstractions are more vulnerable because of the lack of natural protection layers. The travel time of the contamination is much shorter therefore prompt actions must be taken. On the Tisza pilot area, we are focusing on the surface drinking water abstractions located at Szolnok (River Tisza) and at Balmazújváros (Keleti Main Channel) (*Fig. 1*), however BMPs have not been tested at Balmazújváros – Keleti Main Channel Waterworks, only on River Tisza, between Szolnok and Kisköre.

The Szolnok Surface Waterwork is situated in the north-eastern border of Szolnok (*Fig. 1*), on the right side of River Tisza. The capacity of the waterworks is 50.000 m^3/day, the settlements supplied are: Szolnok and 7 surrounding settlements (Rákóczifalva, Rákócziújfalu, Szajol, Szászberek, Újszász, Zagyvarékas and Tószeg; *Fig. 2*).

Balmazújváros – Keleti Main Channel Surface Waterworks is situated on south-eastern part of Balmazújváros outer area (*Fig. 1*), on the right side of the Keleti Main Channel. The water treatment plant is situated 1 km from the water abstraction, in east of the Keleti Main Channel. The capacity of the waterworks is 30.000 m^3/day, the treated water is 13.000 m3/day. The settlements supplied with exclusively treated surface drinking water are: Nagyhegyes, Nagyhegyes-Elep, Balmazújváros-Nagyhát, Debrecen-Nagymacs, and Debrecen-Ondód (*Fig. 2*). Debrecen and Debrecen – Józsa district are supplied with mixed water (treated surface water and groundwater).

Objectives of pilot action are (1) stakeholder involvement, (2) testing of BMP's in livestock farming and plant production through comparison of current state of the pilot area and an area in Hungary which has already been monitored for possible surface water contamination coming from agriculture, and (3) data gathering and evaluation (water stage levels, precipitation, water chemistry).

Earlier we identified three GAPs describing the most problematic areas in the relationship between land use and drinking water protection to support the decision making processes in the future.

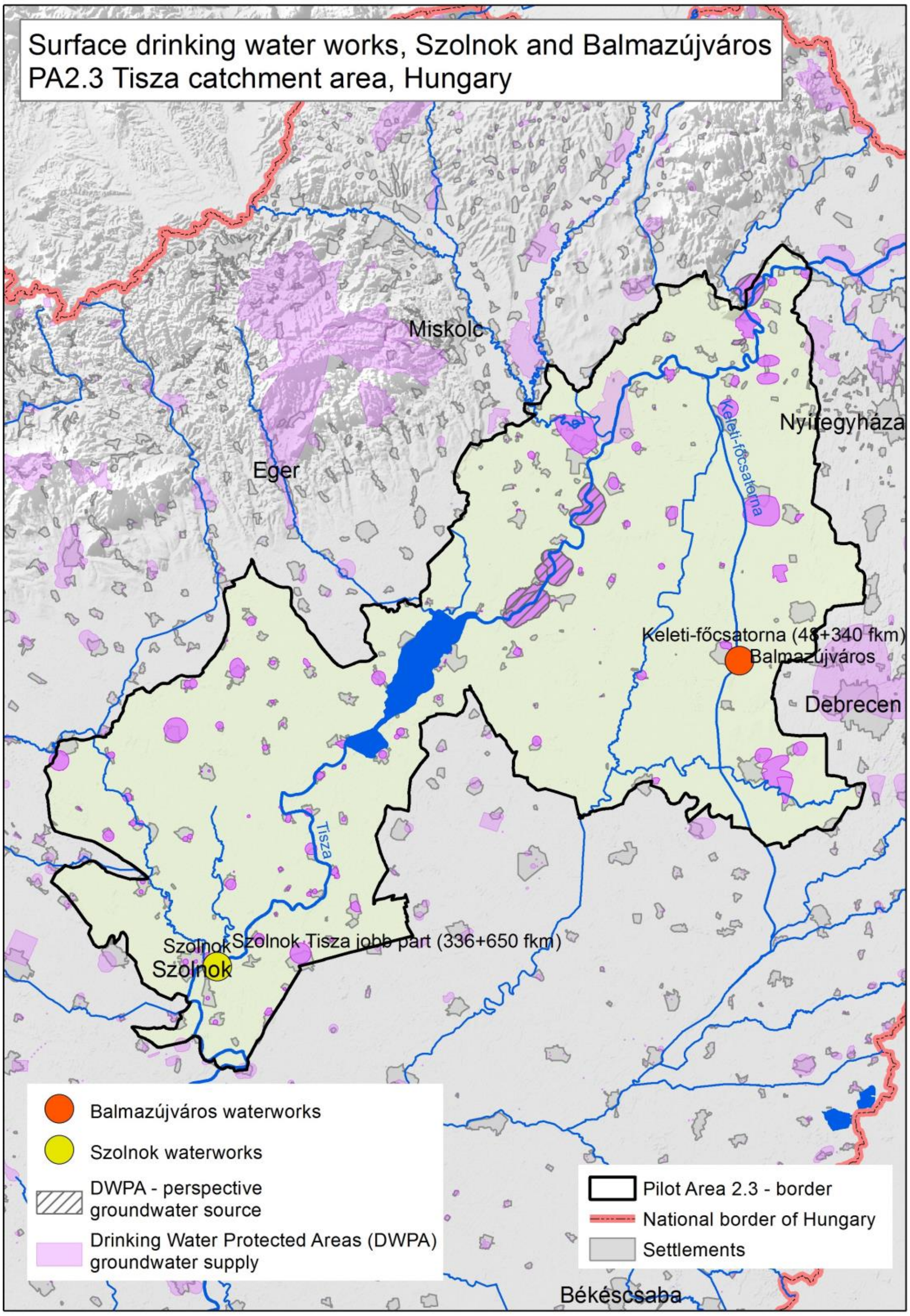

Figure 1: Surface drinking water works on PA2.3 Tisza Catchment

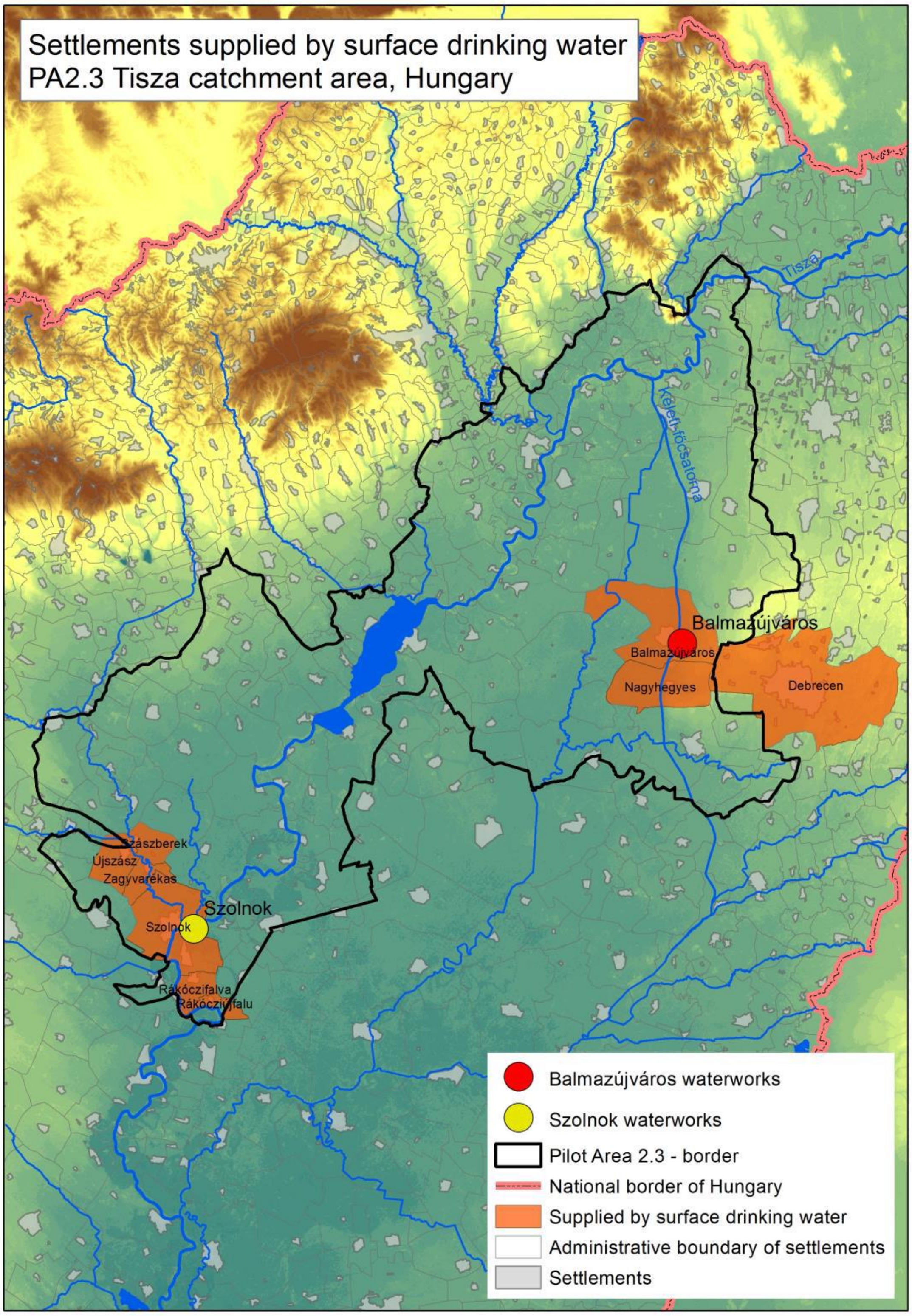

Figure 2: Settlements supplied by surface drinking water on PA2.3 Tisza Catchment area

2.2. BMPs of Pilot Action

▪ Identified GAP provoking action	
GAP short name	**The impact of livestock and manure on surface water resources**
GAP short description	The access of manure and liquid manure into watercourses near livestock farming areas could affect negatively the quality of the surface water resources.
▪ Best management Practice / Management Action	
Name of BMP	**Livestock farm practices for drainage, management, and utilization of rainwater; usage and storage of manure.**
Type of land use regarded	Agriculture
Location	Various sites along River Tisza on the pilot area
BMP description	Inner and outer protective areas have been designated for the Szolnok surface drinking water abstraction, but riparian zone conditions outside of the protective areas still have significant impact on water quality. On the score of riparian livestock farms, it is important that no contaminants from manure shall be picked up by the natural runoff and transported directly into the watercourses. The formation of contaminated rainwater must be moderated. This can be done by harvesting, draining off and placing separately the rainwater from clean surfaces. The extent of manure contamination should be reduced. Good practise for harvesting and managing contaminated rainwater on livestock farms should be worked out. Contaminated rainwater could be treated by leachate on the manure holding sites or it can be placed on arable land considering the relevant legislation. Manure storage is related to this subject. Proper design and handling of closed manure storage facilities could keep manure from leaching and could stop water runoff contaminated by manure. Risk of leaching is directly proportional to the time unmanaged manure piles spend on the agricultural land sides, therefore the manure should be spread as soon as possible.
Advantages of this BMP in PA	With these simple methods, manure and its valuable nutrients can be retained for agricultural utilization.
Challenges of this BMP in PA	Increased monitoring of riparian livestock farms is necessary. Closed manure storage facilities were construct, although in many cases their design is not proper, and handling is incorrect. Setting up systems for draining off, utilizing and placing rainwater is not a general practise.
Relevance	Water protection functionality: high Cost of the measure: moderate

	Duration of implementation	medium term
	Time interval of sustainability	sustainable with regular maintenance
Limitations	Livestock farming is not limited on the given area and can be managed in compliance with the law.	
Comments		
References / sources	Survey of livestock farms on the area of Ipoly and its tributaries.	

Identified GAP provoking action	
GAP short name	**Impact of agriculture on surface drinking water resources - plant production**
GAP short description	The quality of surface drinking water resources can be significantly affected by riparian agricultural utilization.
Best management Practice / Management Action	
Name of BMP	**Use of manure and pesticides, participation in the Agrarian Environment Program.**
Type of land use regarded	Agriculture
Location	Section above Szolnok Intake Structures along River Tisza, section above Balmazújváros Waterworks
BMP description	The most significant impact on the surface water quality is the access of contaminated grit into watercourses. This can happen through surface runoff transport. It follows that the effects can be mitigated by reducing surface runoff and stopping contaminated material deposition on riparian areas. It is essential that the shoreline be accompanied by a lane of broader natural vegetation. The presence of contiguous lawn is favorable. Inner and outer protective areas have been designated for the Szolnok surface drinking water abstraction, but riparian zone conditions outside of the protective areas still have significant impact on water quality. In manure management the quantity does not make that much difference, but unmanaged manure piles should spend less time on the agricultural land sides, the manure should be spread as soon as possible. If ploughing runs parallel to the watercourse it could hinder surface runoff to access the watercourse. In the riparian areas, plant treatments should be precocious during weed control, given that it could increase the likelihood of the access of pesticides into the watercourse by surface runoff. Soil disinfection can be applied only in the most necessary cases in the riparian areas. Plant protection activities on riparian areas are regulated by the FVM Decree 43/2010 (IV.23) on plant protection activities, and, on the protection areas of

	drinking water resources, by Government Decree 123/1997 (VII.18) on the protection of water resources. In the case of sloping terrain towards a waterbody, the risk of runoff increases, so the use of defense equipment should be also increased. Surface runoff is significantly affected by cultivated plants. Growing wheat, especially autumn wheat, solve the problem of land coverage in most of the year. Wheat stocks are dense enough to decrease surface runoff. In case of root-crop stocks, where density is not that high, surface runoff can be decreased by applying proper ploughing orientation, in other words ploughing parallel to the near watercourse. In the case of short growing vegetation, the free soil surface increases the degree of erosion, which can be reduced by second planting methods. Land coverage can be ensured by planting species suitable for green manure. This technique could also improve the soil quality. Agri-environment packages include elements important to the quality of surface water, ensuring the longest possible soil cover, controlling the ratio of crops to crops, rules on fertilizer application, green fertilization, use of environmentally friendly pesticides, etc. The water erosion control practices program applies to areas with slopes greater than 12%. In this case, smaller sloping areas are also counted. Decree 10/2015. (III 13) FM is a guideline on the use of support for agricultural practices beneficial to the climate and the environment, on the conditions under which arable land, permanent grassland and land covered by permanent crops are fit for cultivation or grazing, and also promotes the proper maintenance and restoration of water protection zones.
Advantages of this BMP in PA	The methods proposed for use are not complicated, traditionally used in cultivation. Their application also represents an advantage in cultivation along with a favorable environmental protection and water protection effect. In case of participation in the Agrarian Environment Program, the lost income is compensated by the program.
Challenges of this BMP in PA	On the riverbank, a natural vegetation band must be maintained or created. Farmers on riparian areas should be included in the use of environmentally friendly production methods, and in the participation in the agri-environment program. Enhanced monitoring is required to comply with existing general environmental, soil protection and pesticide use standards.
Relevance	Water protection functionality: high Cost of the measure: moderate Duration of implementation: medium term Time interval of sustainability:
Limitations	The provisions of the legislation in the hydrogeological water basin protection

	area limit those highly polluting activities in agriculture, which are not part of the general cultivation practices.
Implementation of the BMP in PA	Monitoring the land use along river Tisza between Szolnok Intake Structures and Kisköre
Comments	-
References / sources	Survey of agricultural lands along Ipoly and its tributaries, on the section above Komravölgyi Reservoir.

▪ Identified GAP provoking action	
GAP short name	**Operation of surface drinking water facility at flood time**
GAP short description	In case of high water, with increasing water level, the problems with the operation of the Szolnok surface waterworks are intensified.
▪ **Best management Practice / Management Action**	
Name of BMP	**Reduction of flood effects on the surface drinking water resources**
Type of land use regarded	Agriculture/ urban/ riparian forest
Location	Tisza, Szolnok, Surface Drinking Water
BMP description	The Szolnok Surface Water Plant supplies 8 settlements besides Szolnok with drinking water, with a standard capacity of 60,000m^3/day. Tisza is a river with extreme water regime and its water quality varies widely. The surface water of the river Tisza is treated in a water purification plant, which is able to adapt to the changing raw water quality requirements with its versatile cleaning elements and grades. The security of water supply was also created in the case of emergency water pollution in Tisza, when the water of the Tisza is unsuitable for drinking water. Spare water base for Alcsi Holt-Tisza. The reserve water base can provide enough water for 2-3 weeks with the 50% capacity of the water purifier. The production of deep wells can also assist in the supply of drinking water if necessary. The Nagykunsági flood-reducing reservoir in the upper section of Tisza over Szolnok reduces the height of the flood level and makes the flood event more balanced. The Waterworks is prepared for operation under floods for which a flood management regulation is required.
Advantages of this BMP in PA	Reducing flood peaks also reduces the operational risk of the surface drinking water resources. At the surface preparation is indispensable for floods and the management of water quality changes, especially at the extreme water regime of the Tisza. As a result of the preparedness and the established water

	purification technology, the supply of drinking water in case of bankfull is undisturbed. Flood reservoir makes water regime more equitable.	
Challenges of this BMP in PA	Extreme water regime and the resulting water quality effects pose challenges to the production of appropriate quality drinking water. Besides reducing the flood peaks, water supply facilitates more equitable water regime in the case of small waters.	
Relevance	Water protection functionality	high
	Cost of the measure	high
	Duration of implementation	long term
	Time interval of sustainability	long term
Limitations	High cost of measure	
Implementation of the BMP in PA	The operator of the Szolnok Surface Waterworks has developed the operating system for bankfull and small water, so Waterworks can supply its drinking water service in these extreme situations. The flood reservoirs along the Tisza River reduce the flood peaks, it affects the Szolnok Surface Waterworks. Water storage facilities will also available in the Nagykunság reservoir. The water purification technology is suitable for the treatment of changing water quality.	
Comments	-	
References / sources	-	

3. Activities in the Pilot Action

In PA2.3 Tisza Catchment area, with a special emphasis on the area between Szolnok and the Kisköre Reservoir, three GAPs were previously identified. In order to solve those potential problems, we also came up with ideas for best management practices. For testing those BMPs it is crucial that we clarify the current situation and assess the magnitude of the problems (GAPs).

3.1. Overview

Table 1: Activities in Pilot Action.

<table>
<tr><td rowspan="6">Activities</td><td colspan="3">(1) Introducing GAPs to stakeholders (stakeholder involvement)</td></tr>
<tr><td colspan="3">(2) Testing of BMPs</td></tr>
<tr><td>BMP1</td><td>BMP2</td><td>BMP3</td></tr>
<tr><td>- localization and identification of manure storages on the pilot area
- comparing water chemistry data, precipitation reports, and water stage level reports (2012-2018 period)
- compare the situation with the results of another case study</td><td>- comparing water chemistry data, precipitation reports, and water stage level reports (2012-2018 period)</td><td>- comparing water chemistry data, precipitation reports, and water stage level reports (2012-2018 period)</td></tr>
<tr><td colspan="3">(3) Prioritisation of GAPs</td></tr>
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3.2. Stakeholder involvement

The first national stakeholder workshop for the PROLINE-CE project was held on June 7th, 2017 in the Conference Centre of Herman Ottó Institute (HOI), in Budapest. The workshop was part of the thematic work package T1: Capitalization: Capacity Building and Stakeholder Engagement.

The aim of the workshop was to present the framework, the objectives and goals of the PROLINE-CE project, as well as the results achieved so far to the participating representatives. As organisers we targeted to reach a broad range of stakeholders in order to gain a good insight into the challenges of drinking water resources protection, thus we invited participants from various domains. Universities, scientific institutes, water management bodies, ministries, national parks, mayor's offices mainly from those counties where the pilot areas are situated, and NGOs concerned with environment and water protection. The input provided by the target groups is essential in further developing best management practices in land use for drinking water protection and flood/drought mitigation.

After the lunch break the participants returned for the discussion and were asked to discuss the selected topics. The moderated discussion became very lively and different opinions were debated. The discussion was moderated by the representatives of the PP HOI and PP OVF.

The topics were:

- efficiency of legislation on protection of drinking water resources
- vegetation regulations interventions on floodplains (flood risk management)
- draught strategy – effects of irrigation development on water resources
- as a specific discussion theme, the question of agro-forestry was raised, which generated very lively discussions later on, around the end of the workshop.

Items discussed and considered as important to deal with in the continuation of the project:

- In Hungary forests appear as clusters not as land cadastre data
- it would be desirable to turn some agricultural areas into wooded lands
- need for enhancing the adaptation potential is important
- promotion of "Silva pastorata" initiative supporting the regulated grazing in forested areas, even in orchards
- European Union practices are more flexible than Hungarian ones
- greening is an important issue
- need to turn towards a complex landscape utilization
- it is crucial the arrangement of land ownership situation
- use of remote sensing could be an efficient tool
- targeting a water catchment level thinking/approach
- reasonable development of irrigation; not only investments should be done as development but a reasonable and cost efficient management is desirable as well.

The 2nd national stakeholder workshop for the PROLINE-CE project was held on May 31st, 2018 in the headquarter of the Middle Tisza District Water Directorate, in Szolnok. The workshop is part of the thematic work package T2: Stakeholder Involvement.

The aim of the workshop was to present the framework, the objectives and goals of the PROLINE-CE project in general, as well as the results achieved so far with a special emphasis on the relationship between the climate change and best management practices for source water protection in PA 2.3 Tisza Catchment area. As organisers we targeted to reach a broad range of stakeholders in order to gain a good insight into the challenges of drinking water resources protection, thus we invited participants from various domains such as water management bodies, ministries, national parks, mayor's offices situated in the pilot area. Although the invitation to the workshop was widely distributed, the participation was narrower than expected in terms of professional diversity, most of the participants came from the water sector.

For the roundtable discussion GAPs were presented, namely

- the impact of livestock and manure on surface water resources,
- the impact of agriculture on surface drinking water resources – plant production,
- operation of surface drinking water facility at flood time,

the question “how climate change could/will worsen the situation” was raised and questions were addressed to the stakeholders about each GAP and how the present stakeholders think they can participate in the project. Everyone agreed that the raised problems are very complex, and that although **the situation** might **seem to be under control at the moment, the climate change could be a serious threat. It was also said that monitoring the water quality of River Tisza is enough, there is no need to monitor its tributaries.**

3.3. Data gathering and evaluation

3.3.1. Livestock farms (BMP1)

In the framework of the national *River Basin Management Plan II* an assessment took place in 2010 and 2014 to identify the types of manure storages on livestock farms on a national level. For this report manure storages on the pilot area were selected and are shown on *Fig. 3*. It is most likely that the situation has not changed much since then.

As shown in *Fig. 3* and as it was noted in the GAP description, manure heap is the most common storage type above Szolnok Intake Structures, and, unfortunately, other “open” storing facilities are in use, such as watertight, insulated concrete foundation, rammed earth foundation, non-insulated earth foundation. For liquid manure storage and leachate collection insulated concrete pits with leak-proof drainage system are used. Other manure storage types are: earthen pond covered with 2-2.5 mm HDPE foil (certified), non-insulated concrete pool, insulated, watertight concrete pool (only in one case), earthen pond with foil lining, non-insulated earthen pond.

A survey related to the impact of livestock and manure on surface water resources took place on the Hungarian section of River Ipoly, above the Komravölgyi Reservoir and along Ipoly’s tributaries on the riparian livestock farms in 2015. The survey was carried out in the framework of *Joint Ipoly Catchment Management (HUSK/1101/2.1.1/0153)* project. The result of the survey along River Ipoly was that no contaminated water got into any of the watercourses, no contaminated water runoff came from livestock farms, and the water was classified as good quality water overall. Based on these results a comparison of current manure storing practices on the Ipoly area and Tisza Catchment area was made in the pilot action. To do so manure storage types on the Ipoly area were also selected and are shown on *Fig. 4*. The aim of the comparison was to narrow down the issue and concretize those manure storage practices which need to be avoided.

The one main difference between manure storing practices on the two areas is that along River Ipoly manure heaps are less common. (Note that the comparison by itself is only gives an overall idea but not enough to test BMPs, it has to be combined with data from precipitation, water stage level reports and runoff coefficient of the Ipoly area, which data are unavailable at the moment.)

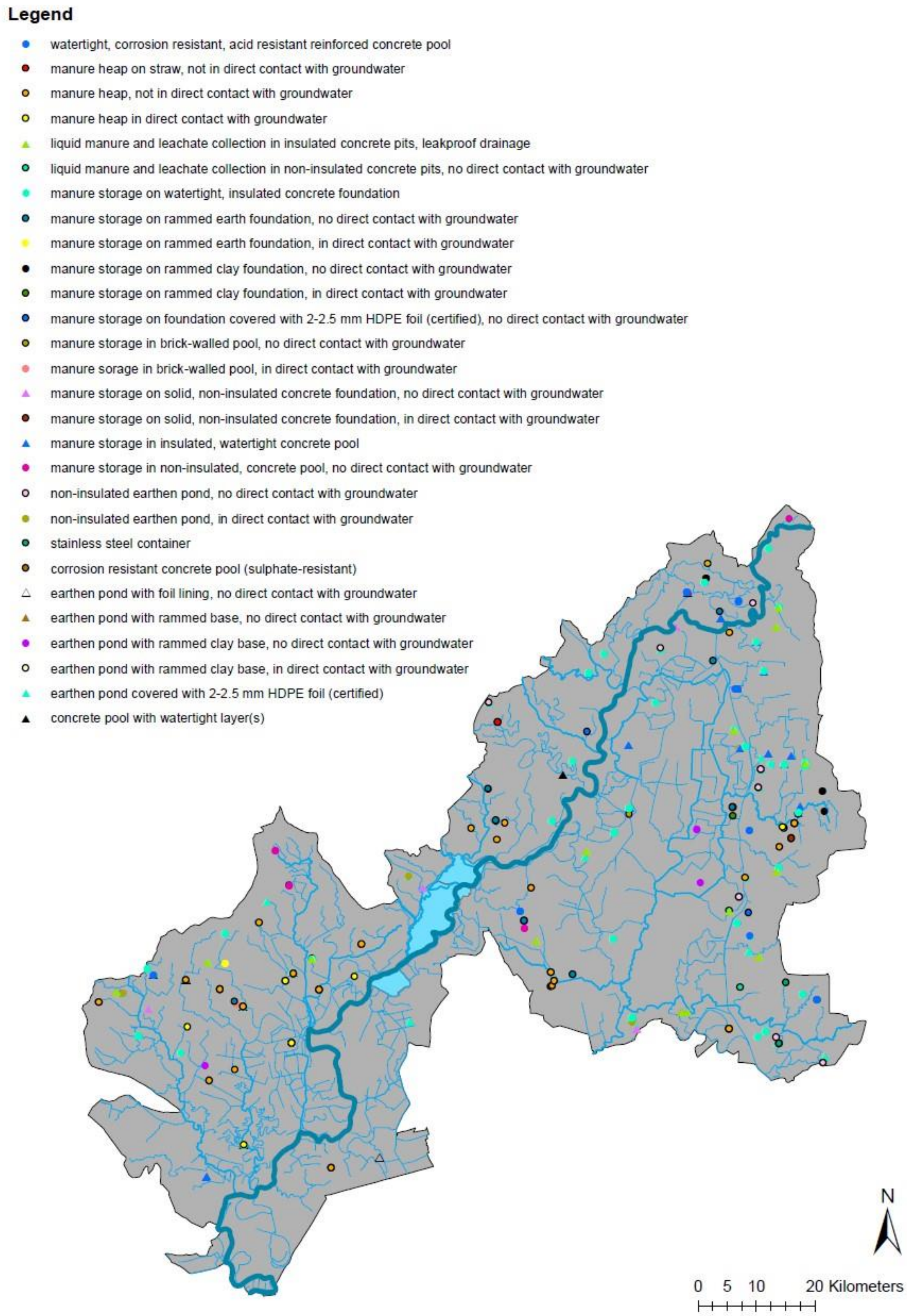

Figure 3: Different types of manure storages on pilot area.

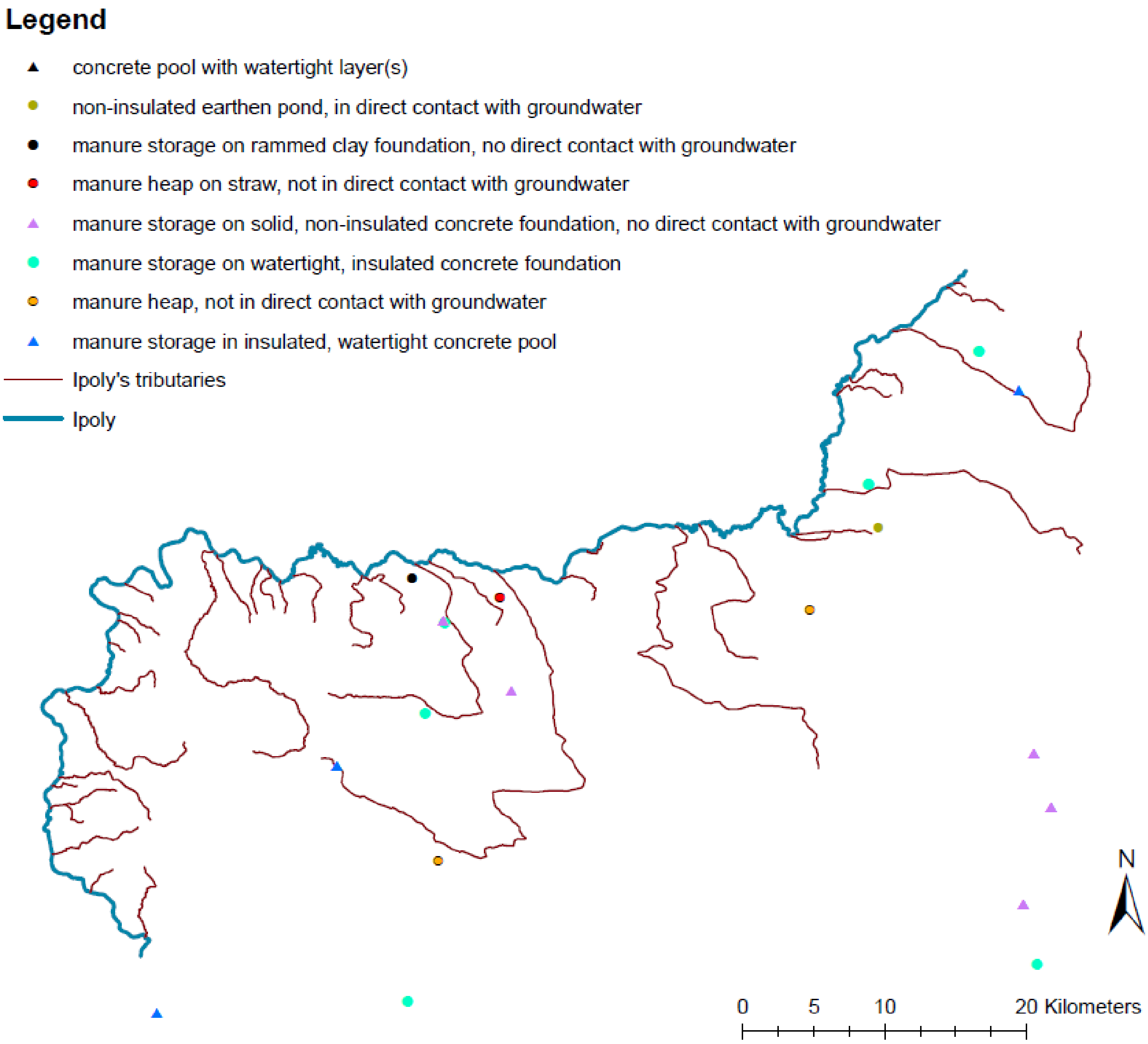

Figure 4: Different types of manure storages along River Ipoly, Hungary.

3.3.2. Water chemistry (BMP1-2-3)

Szolnok Waterworks has made available their water chemistry reports and water stage level reports of the past six years. *Diagram 1-5* in Appendix show the correlation between water stage level changes and changes in water chemistry (parameters: NO_3^-, COD_{Mn}, NO_2^-, NH_4-N, pH - limit values of these parameters and water quality classes are shown in Table 1.), *Diagram 7-11* in Appendix show correlation between precipitation and water chemistry. (Precipitation data is from www.metnet.hu.) On the diagrams flood warning level I, II, III are shown as well as limits of the five water quality parameters (Table 1 in Appendix). The following correlations have been outlined:

- NO_3^-
    - the changes of NO_3^- amount are in positive correlation with water stage level changes;
    - the increase and decrease of NO_3^- amount showed a regular pattern in the last / years, in general during the winter it exceeds the limit of class III (tolerable), decreases at late spring/ early summer (at the end of spring flood season) and stays between 1-5 mg/L (class II, good);
    - it seems to be independent from precipitation;
- COD_{Mn}
    - values were mostly in class I (excellent) through the last six years, two times it exceeded limit of class IV (contaminated), January 2013 and December 2016;
    - values are in fairly positive correlation with water stage levels, and fairly negative correlation with precipitation;
- NO_2^-
    - 2012 was overall a very dry year with an extremely hot summer, throughout the year the amount of NO_2^- was most of the time tolerable (class III), two times it exceeded the limit of class IV (contaminated) with the values 0.31 mg/L and 0.39 mg/L;
    - from 2013 the amount of NO_2^- dropped back to 0.03-0.1 mg/L (class II, good);
    - it seems to be in weak negative correlation with water stage levels and precipitation;
- NH_4-N
    - over the last six years the amount of ammonium was mostly below 0.2 mg/L (class I, excellent);
    - the amount of ammonium is in negative correlation with water stage level and precipitation;
- pH
    - most of the last six years pH at Szolnok was between 7.5-8.0 (class I, excellent);
    - its value is in weak/ moderate negative correlation with water stage level and precipitation.

3.3.3. Surface runoff

While identifying GAP1-2 we drew up the possibility of contaminants being washed off from livestock farms and plant production areas via surface runoff. Due to geographical characteristics of the pilot area (*Fig 5*) this problem does not seem to be imminent **at the moment**. The percentage of water originating from in situ precipitation is negligible due to (1) the amount precipitation is quite low on this area; (2) water cannot run off gravitationally on the flat terrain, instead it evaporates back to the atmosphere or infiltrates into the soil (ZSUFFA et al., 2004) The runoff coefficient of the Hungarian Great Plain, where the pilot area is situated, is 0.1, while the annual mean runoff is ~30 mm (LÁSZLÓFFY, 1982). This is because a high proportion of rainwater evaporates from the plain due to residence time, high temperature and radiation.

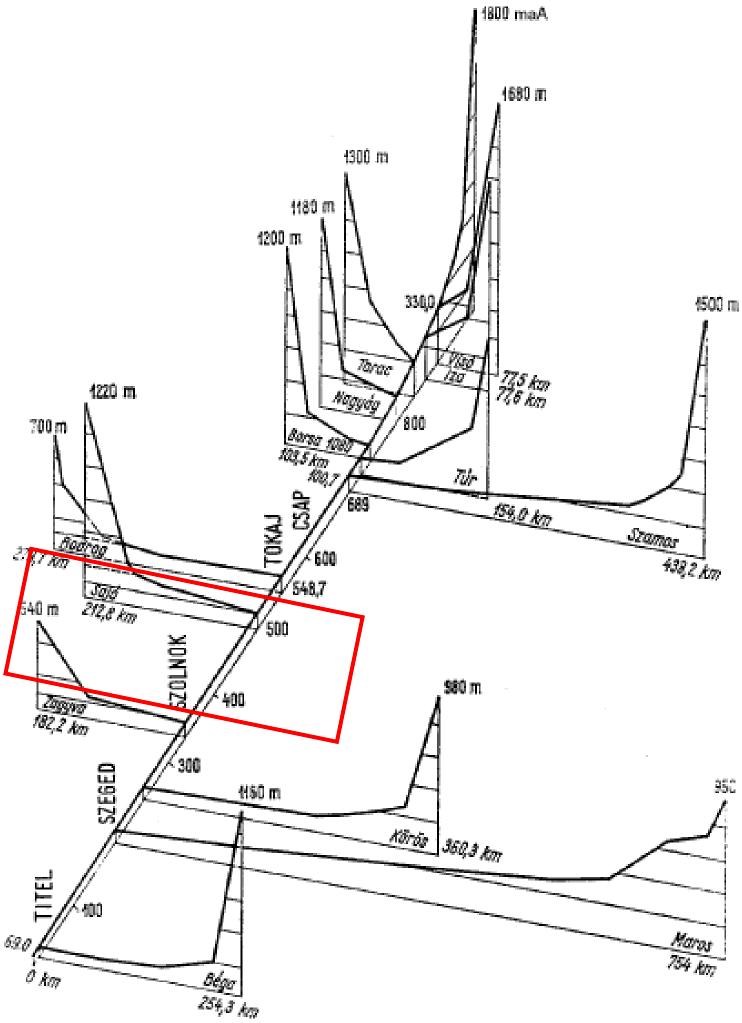

Figure 5: Slope conditions within the Tisza basin. Red square indicates pilot area. (after Lászlóffy, 1982)

4. Solutions for case specific adaptation of best management practices

Table 2: GAPs and proposed BMPs with recommendations for implementation in Pilot Action.

Actual management practice (GAP)		Improper manure storage	Improper or excessive use of pesticides and manure on plant production fields.
Proposed BMP		Frequently monitoring livestock farms (authorities), providing information to the farmers about the environmental disadvantages of improper manure storage and about climate change.	Involving farmers to the Agrarian Environmental Program, emphasizing the importance of green products, providing information to the farmers about climate change.
Proposed solutions and recommendations	adaptation of existing land use management practices	Closed manure storage facilities, managing and collecting rainwater (better drainage systems on livestock farms).	Ploughing parallel to the watercourse, usage of green products
	Adaptation of existing flood/drought management practices	Collecting rainwater could be advantageous in drought periods.	Not relevant
	Adaptation of policy guidelines	Guidelines for farmers about manure storage.	Not relevant
Remaining issues to be solved		Solve the problem of frequent monitoring of livestock farms with or without involving the authorities, preparing for climate change.	Forecasting how plant production will change as climate changes could be advantageous.

Actual management practice (GAP)		Increased contamination of surface drinking water resources during flood events.
Proposed BMP		Reducing flood effects on surface drinking water resources.
Proposed solutions and recommendations	adaptation of existing land use management practices	Change of agricultural practices in riparian areas.

	Adaptation of existing flood/drought management practices	Current flood management practices are good, but preparation for extreme flood events caused by CC seems to be necessary.
	Adaptation of policy guidelines	Guidelines for agricultural practices in riparian areas.
Remaining issues to be solved		Farmers have to preparing for climate change.

5. Conclusions

Data evaluation and comparisons highlighted that current practices in livestock farming, plant production and flood mitigation are good enough to keep the raw surface water in an overall good quality. Data on chemical parameters (NO_3^-, NH_4-N, COD_{Mn}, NO_2^- and pH) measured at Szolnok *(Szolnok Waterworks)* were evaluated and showed very few momentary contamination events from the last six years. Although on most of the livestock farms open manure storages are still in use, the runoff coefficient is so small on the pilot area that the water originating from in situ precipitation is negligible. Overall few annual precipitation, high temperature and radiation contribute to the fact that contaminated rainwater rather evaporates back to the atmosphere or infiltrates into the soil. Water quality did not deteriorate considerably during the serious flooding in 2013 either.

The above shows that the situation is satisfying at the moment. The problem lies in climate change and how it is going to affect the efficiency of the current practices. For instance, open manure storages may not pose a big threat in the current climate conditions, but an extremely intensive rainfall could possibly trigger a surface runoff, even on a flatter land, which could contaminate the nearby watercourses. As it was mentioned by Brunetti et al. (2001) and Bates et al. (2008) (and many more) for countries in the temperate zone, climate change will decrease the number of rainy days but increase the average volume of each rainfall event.

Current practices should be evaluated in context of future climate conditions.

6. References

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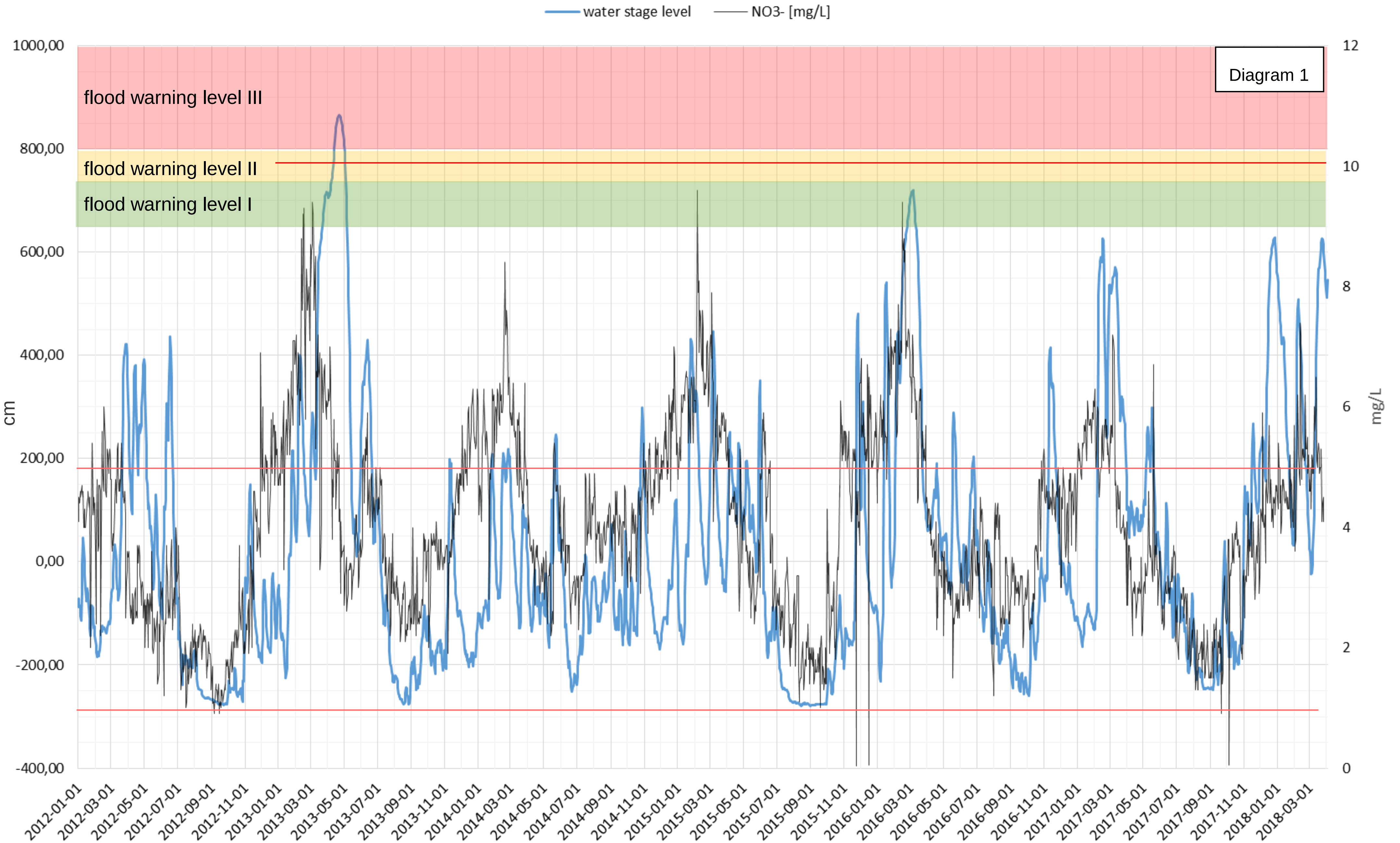
- River Basin Management Plan II
- Joint Ipoly Catchment Management (HUSK/1101/2.1.1/0153)
- www.metnet.hu

Appendix

1. Table: Limit values for water quality classes in Hungary.

	unit	class I (excellent)	class II (good)	class III (tolerable)	class IV (contaminated)	class V (heavily contaminated)
NO_3^-	mg/L	1	5	10	25	>25
COD_{Mn}	mg/L	5	8	15	20	>20
NO_2^-	mg/L	0.01	0.03	0.1	0.3	>0.3
NH_4^-N	mg/L	0.2	0.5	1	2	>2
pH	-	6.5-8.0	8.0-8.5	6.0-6.5 8.5-9.0	5.5-6.0 9.0-9.5	<5.5 >9.5



water stage level
NO3- [mg/L]
Diagram 1
flood warning level III
flood warning level II
flood warning level I
cm
mg/L
1000,00
800,00
600,00
400,00
200,00
0,00
-200,00
-400,00
12
10
8
6
4
2
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
2013-09-01
2013-11-01
2014-01-01
2014-03-01
2014-05-01
2014-07-01
2014-09-01
2014-11-01
2015-01-01
2015-03-01
2015-05-01
2015-07-01
2015-09-01
2015-11-01
2016-01-01
2016-03-01
2016-05-01
2016-07-01
2016-09-01
2016-11-01
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2017-03-01
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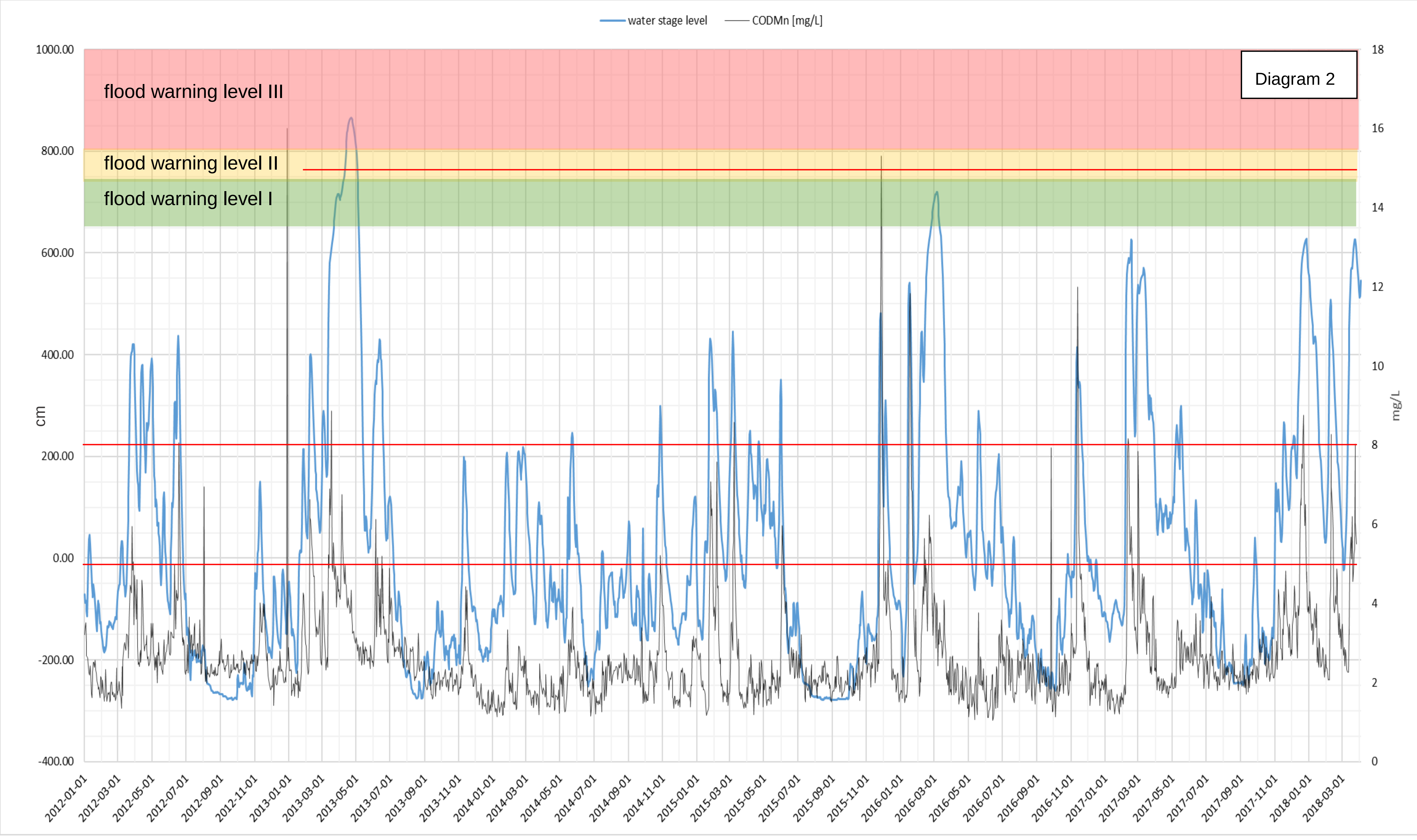
2017-07-01
2017-09-01
2017-11-01
2018-01-01
2018-03-01


water stage level
CODMn [mg/L]
Diagram 2
flood warning level III
flood warning level II
flood warning level I
1000.00
800.00
600.00
400.00
200.00
0.00
-200.00
-400.00
cm
18
16
14
12
10
8
6
4
2
0
mg/L
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
2013-09-01
2013-11-01
2014-01-01
2014-03-01
2014-05-01
2014-07-01
2014-09-01
2014-11-01
2015-01-01
2015-03-01
2015-05-01
2015-07-01
2015-09-01
2015-11-01
2016-01-01
2016-03-01
2016-05-01
2016-07-01
2016-09-01
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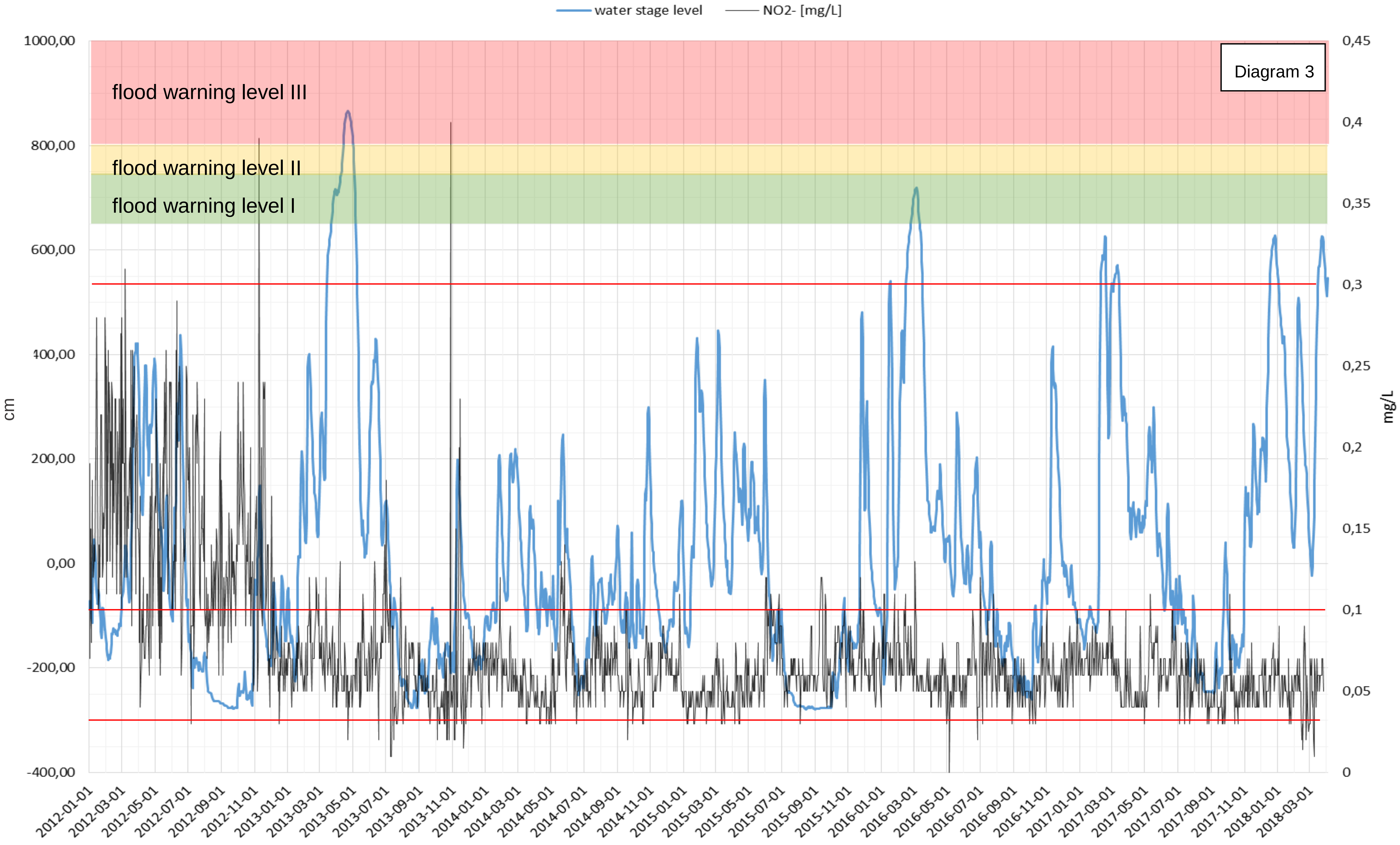
2017-11-01
2018-01-01
2018-03-01



water stage level
NO2- [mg/L]
Diagram 3
flood warning level III
flood warning level II
flood warning level I
cm
mg/L
1000,00
800,00
600,00
400,00
200,00
0,00
-200,00
-400,00
0,45
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
2013-09-01
2013-11-01
2014-01-01
2014-03-01
2014-05-01
2014-07-01
2014-09-01
2014-11-01
2015-01-01
2015-03-01
2015-05-01
2015-07-01
2015-09-01
2015-11-01
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2016-03-01
2016-05-01
2016-07-01
2016-09-01
2016-11-01
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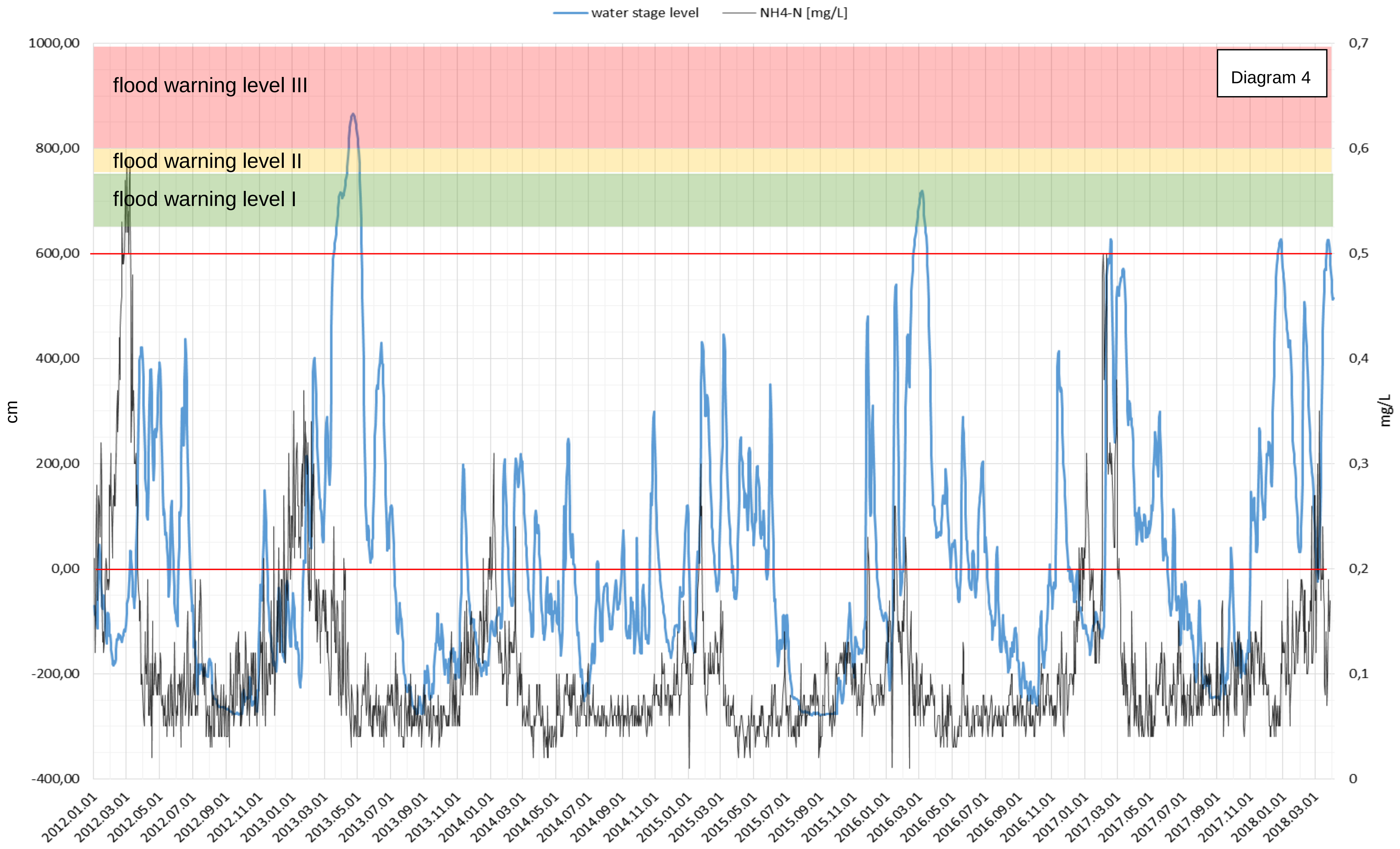
2017-07-01
2017-09-01
2017-11-01
2018-01-01
2018-03-01


water stage level
NH4-N [mg/L]
Diagram 4
flood warning level III
flood warning level II
flood warning level I
cm
mg/L
1000,00
800,00
600,00
400,00
200,00
0,00
-200,00
-400,00
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
2012.01.01
2012.03.01
2012.05.01
2012.07.01
2012.09.01
2012.11.01
2013.01.01
2013.03.01
2013.05.01
2013.07.01
2013.09.01
2013.11.01
2014.01.01
2014.03.01
2014.05.01
2014.07.01
2014.09.01
2014.11.01
2015.01.01
2015.03.01
2015.05.01
2015.07.01
2015.09.01
2015.11.01
2016.01.01
2016.03.01
2016.05.01
2016.07.01
2016.09.01
2016.11.01
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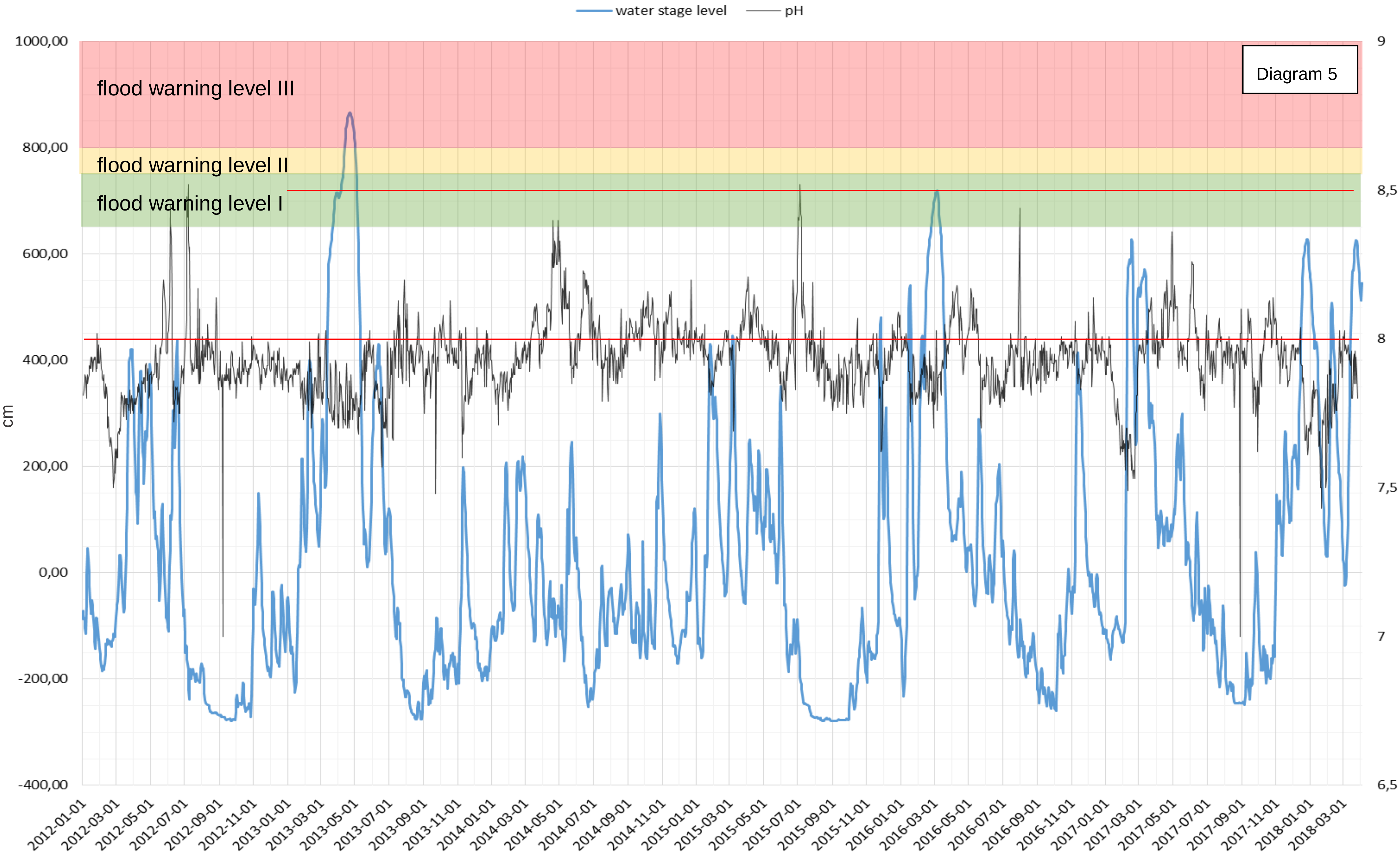
2017.03.01
2017.05.01
2017.07.01
2017.09.01
2017.11.01
2018.01.01
2018.03.01



water stage level
pH
Diagram 5
flood warning level III
flood warning level II
flood warning level I
cm
1000,00
800,00
600,00
400,00
200,00
0,00
-200,00
-400,00
9
8,5
8
7,5
7
6,5
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
2013-09-01
2013-11-01
2014-01-01
2014-03-01
2014-05-01
2014-07-01
2014-09-01
2014-11-01
2015-01-01
2015-03-01
2015-05-01
2015-07-01
2015-09-01
2015-11-01
2016-01-01
2016-03-01
2016-05-01
2016-07-01
2016-09-01
2016-11-01
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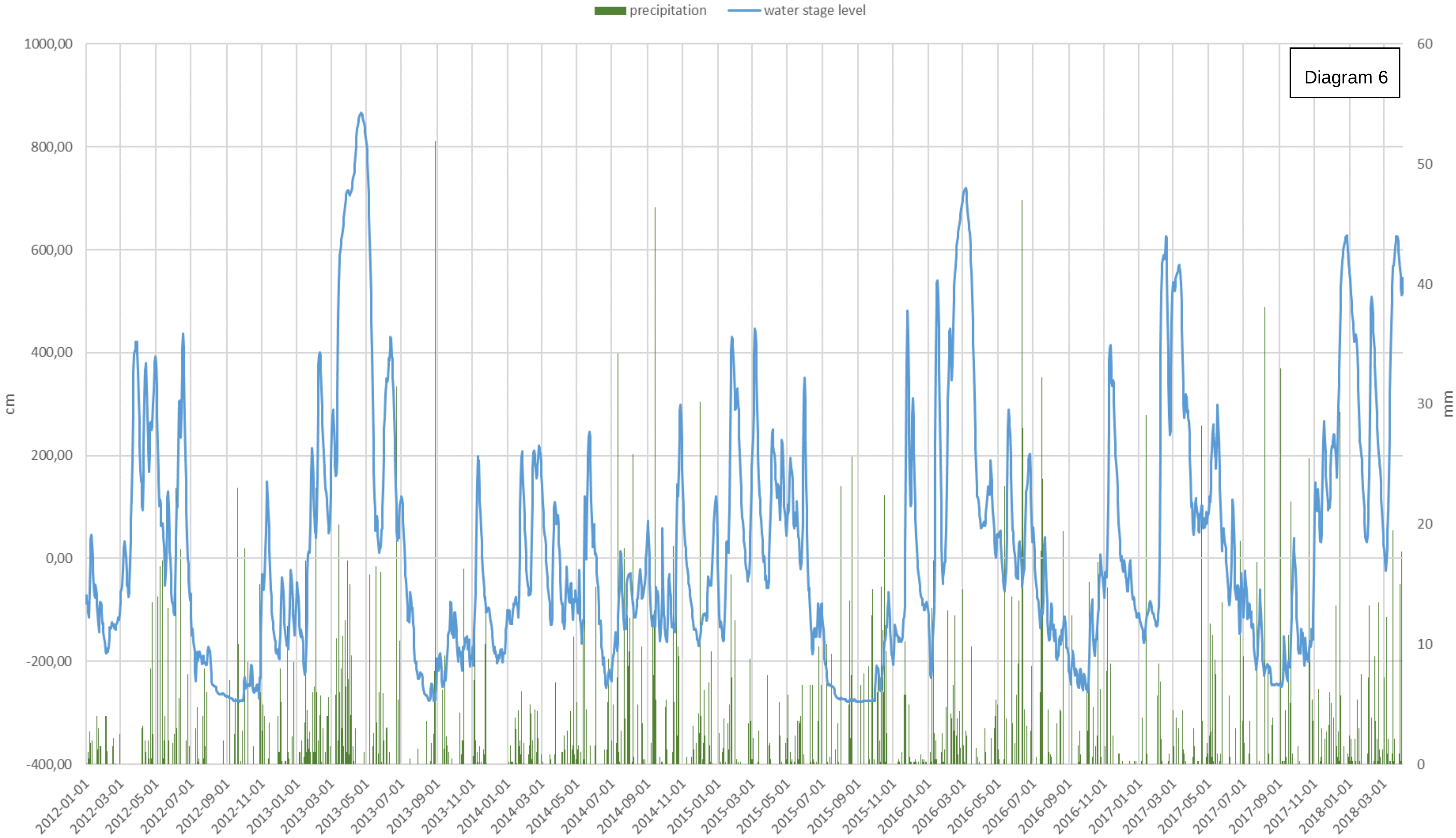
2017-11-01
2018-01-01
2018-03-01


precipitation
water stage level
Diagram 6
cm
mm
1000,00
800,00
600,00
400,00
200,00
0,00
-200,00
-400,00
60
50
40
30
20
10
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
2013-09-01
2013-11-01
2014-01-01
2014-03-01
2014-05-01
2014-07-01
2014-09-01
2014-11-01
2015-01-01
2015-03-01
2015-05-01
2015-07-01
2015-09-01
2015-11-01
2016-01-01
2016-03-01
2016-05-01
2016-07-01
2016-09-01
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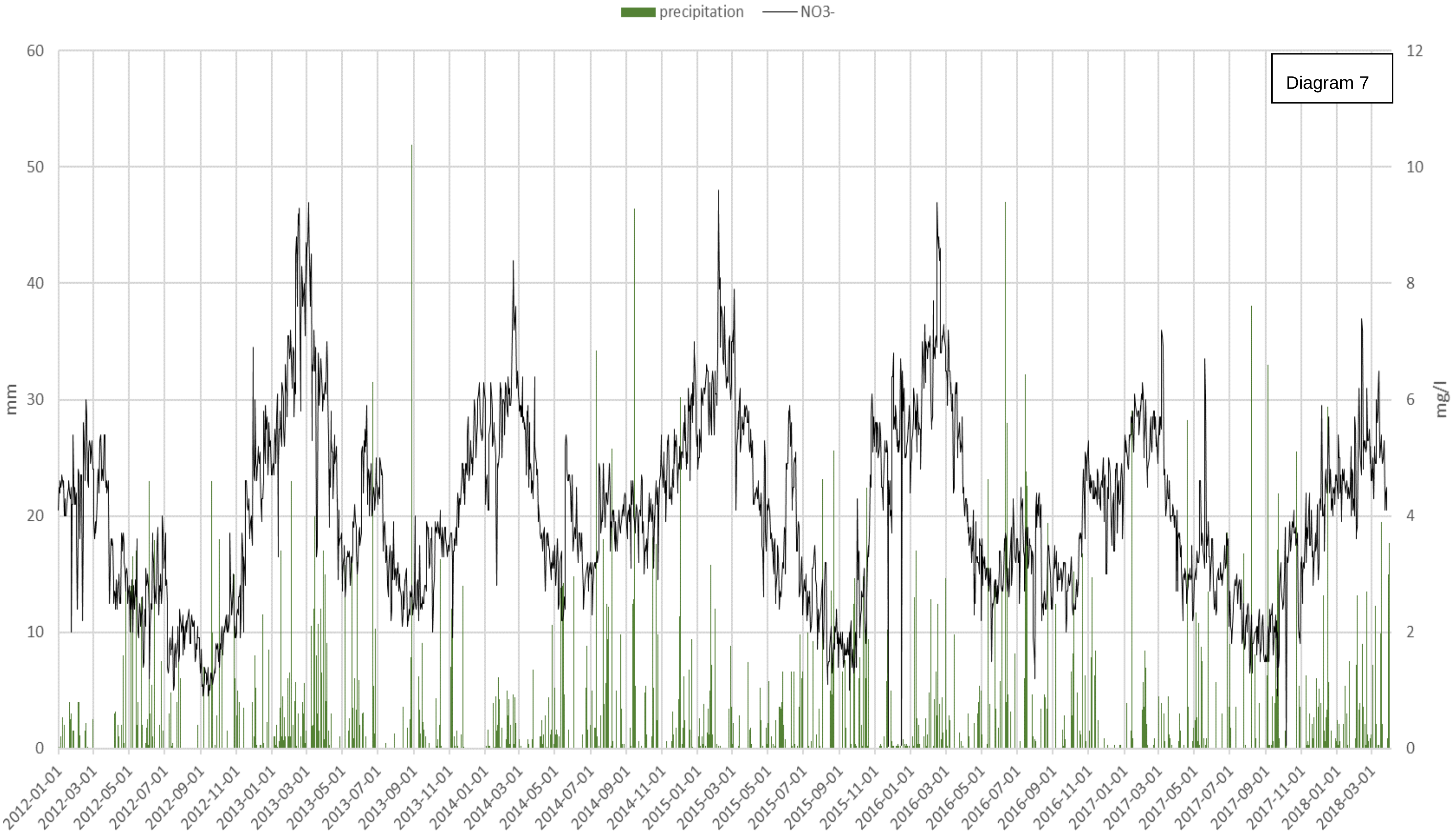
2017-11-01
2018-01-01
2018-03-01



precipitation
NO3-
Diagram 7
mm
mg/l
60
50
40
30
20
10
0
12
10
8
6
4
2
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
2013-09-01
2013-11-01
2014-01-01
2014-03-01
2014-05-01
2014-07-01
2014-09-01
2014-11-01
2015-01-01
2015-03-01
2015-05-01
2015-07-01
2015-09-01
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2016-01-01
2016-03-01
2016-05-01
2016-07-01
2016-09-01
2016-11-01
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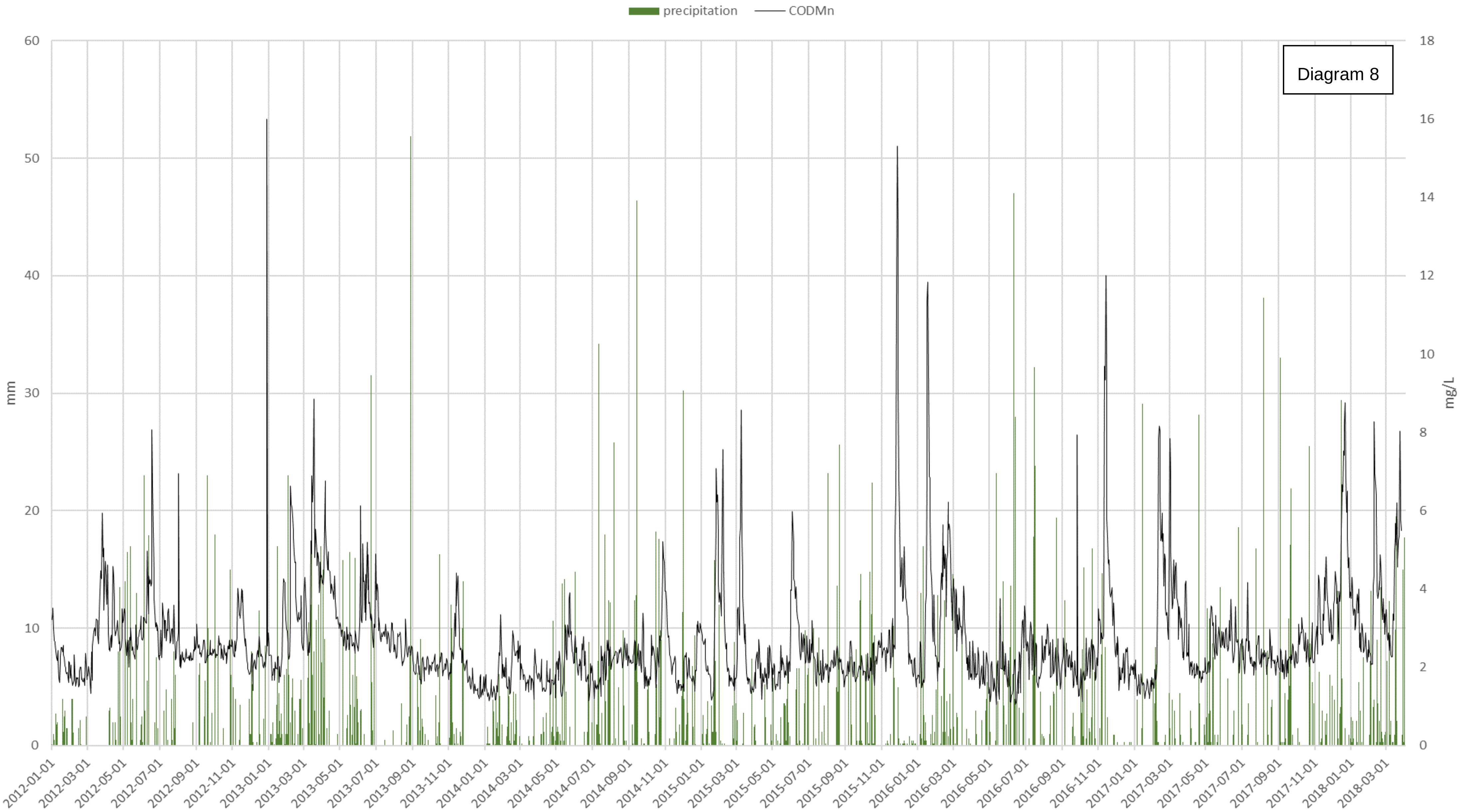
2017-11-01
2018-01-01
2018-03-01


precipitation
CODMn
Diagram 8
mm
mg/L
60
50
40
30
20
10
0
18
16
14
12
10
8
6
4
2
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
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2013-11-01
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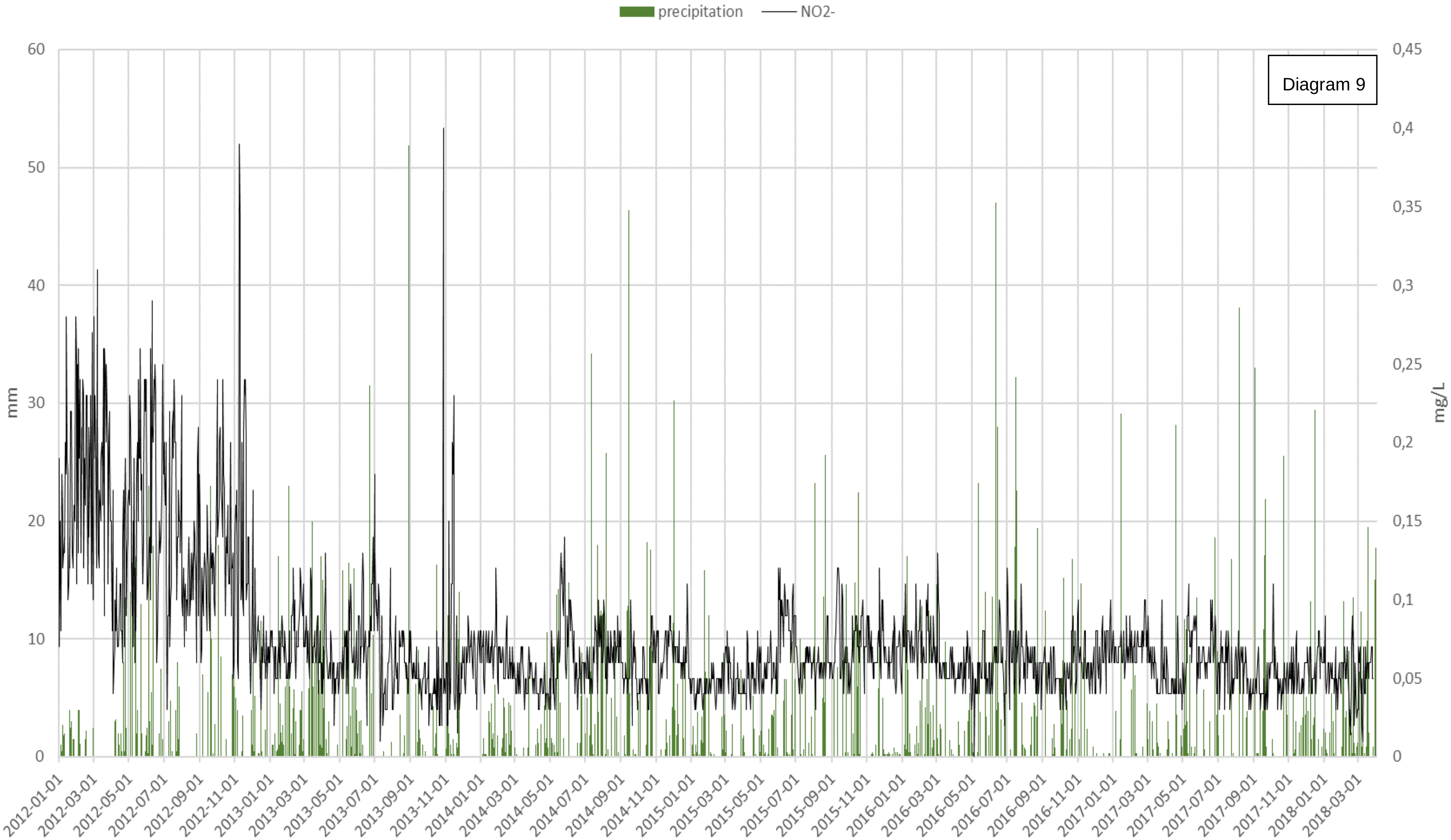
2018-03-01



precipitation
NO2-
Diagram 9
mm
mg/L
60
50
40
30
20
10
0
0,45
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
2013-01-01
2013-03-01
2013-05-01
2013-07-01
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2014-03-01
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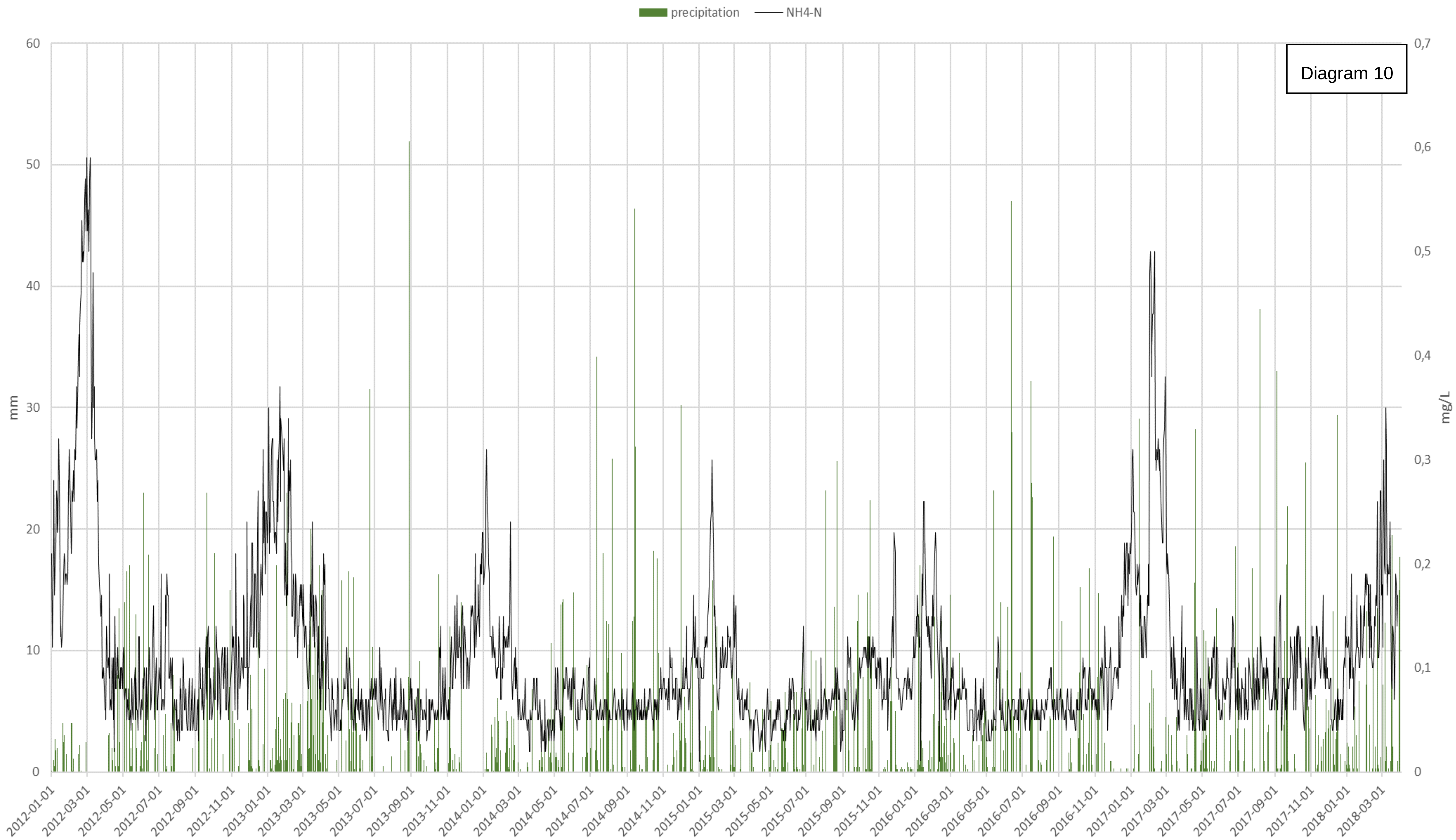
precipitation
NH4-N
Diagram 10
mm
mg/L
60
50
40
30
20
10
0
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
2012-01-01
2012-03-01
2012-05-01
2012-07-01
2012-09-01
2012-11-01
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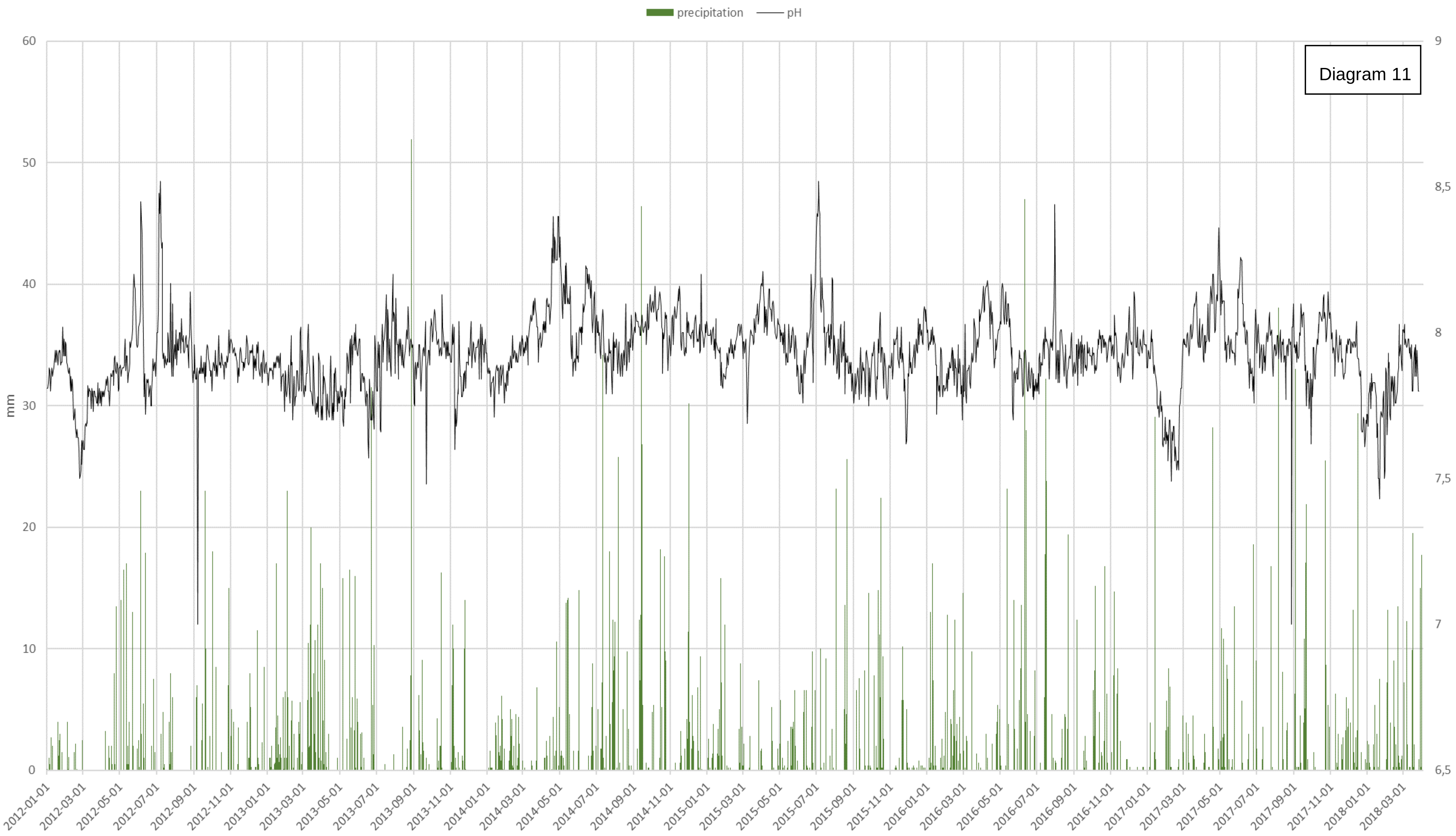
precipitation
pH
Diagram 11
mm
60
50
40
30
20
10
0
9
8,5
8
7,5
7
6,5
2012-01-01
2012-03-01
2012-05-01
2012-07-01
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