Identification of the Zrínyi Ditch – An Engineer Obstacle Built in 1662[1]

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Introduction

In recent years, several papers have been published on the field research of Zrínyi-Újvár. The authors presented the history of the fortress from its construction to the siege of 1664, the results of archival and field research, and the role of the fortress in the defence of Muraköz.[2] The publications also discussed the visual representations of the fortress, in particular, the drawings by Holst, Montecuccoli and Pál Esterházy.[3] This is why it comes as a surprise that – to the best of our knowledge – no one has been engaged in studying, interpreting the role of, or identifying in the field the ditch that can be seen on the drawing by Holst (hereinafter: Zrínyi Ditch). In the following, we will attempt to prove the existence of the Zrínyi Ditch and the possibility to identify it in the field.

"A captain who does not know the land will do little of his own will […]. A ditch, a creek, a straw often caused the fall of armies. It is, therefore, more all-important to know where the hills rise, and the meadows stretch, how the forests can be crossed, and where the waters flow."[4] This quote from Miklós Zrínyi refers to the fact that it is imperative to be familiar with the terrain in order to win a battle. The commanding activities of Zrínyi abound with examples, which prove that he not only described but also knew and used the conditions of the terrain.

One of the best-known examples of this is connected to the construction of Zrínyi-Újvár, where even the selection of location demonstrates his skills. The choice of the place of Zrínyi-Újvár has been examined by many and from lots of different angles, considering both its advantages and disadvantages. For us, those views are relevant that consider the effectiveness of the defence of the fortress and its surroundings in a complex way.

[1] The first publication of the research results was in 2018: A Kaposvári Rippl-Rónai Múzeum Közleményei, (6) 241–254.

[2] Without aiming to give an exhaustive list, here are some outstanding publications on the subject: *Vándor* 1992; *Hausner–Négyesi–Papp* 2005; *Hausner–Padányi* 2012; *Hausner–Padányi* 2014.

[3] The most authentic of these is the black and white drawing by Holst (the colour image of Esterházy is an incomplete copy of this). However, this survived only in the form of a copper engraving by Johann Martin Lerch: *Szalai–Szántai* II. 2006. 159, Plate 217. Originally, it was preserved in the Baden State Library, in Karlsruhe. Lajos Glaser described it in 1933, but it was destroyed during World War II. In Hungary, it was first published in the volume by Szalai–Szántai above, found in their private collection. That is why we can only refer to this. See *Domokos–Hausner* 2008. 241–264.

[4] ZMÖM 2003, Vitéz hadnagy [Lieutenant Vitéz] 328.

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We agree with György Domokos that Zrínyi fully exploited the potentials of the geographical environment. He writes that: “The depictions of the siege clearly show that it was protected from the north and west by the Mura River, from the north-east by the waterlogged valley of the Kanizsa Stream, and from the east by the swamped bed of the dammed Visszafolyó [Backflow] Stream.”[5] As a result of this, although the fortress was besieged by a large number of Ottomans, they had “no access” to it. The siege was restricted to a 250-metre-wide area, allowing defenders to concentrate their forces and inflict maximum damage. This is also evidenced by our field research, which has yielded a large amount of siege finds in that zone.

Exploiting the potentials of terrain in combat

Exploiting the geographical features offered by watercourses and swamps for the purposes of defence was a common practice on the borders of Ottoman Hungary. This was no different for the Mura River and the Kanizsa Stream, either. Guards watching over the ford, outposts established along the river, and the terrain altogether formed a unit that made difficult and slowed down raids and often made them impossible to remain unobserved. The strength of the fortresses and outposts was determined not only by their fortifications but also by their position in the terrain. An example of its recognition is the 1577 session of the War Council. At the meeting there was a debate about the defence of the borderland and the Kingdom of Hungary between two parties holding different views. One focused on active offensive combat and the other on active defence.

The concept finally adopted is briefly the following: “…the most important tool is defence and the reliable and adequate supply of the border fortresses […]. And, indeed, if the enemy sees that the borderland is well occupied, there are plenty of soldiers, and everything necessary for defence and liberation is readily available and in good condition, they will be much more cautious and give up many ventures that they otherwise – if they knew there was no opposition – would undertake, all the more because those things cannot happen so quietly that the enemy would not learn about them. Accordingly, the most important thing is the good and sufficient supply and armament of the border fortresses and frontiers […] to make sure that there are enough troops everywhere on the frontier at all times to repulse the regular attacks and raids of the enemy…”.[6]

The inspection carried out in 1579 was a visible sign of the proposition associated with the name of Lazarus von Schwendi,[7] during which the inspection committee of the War Council also surveyed the valley of the Kanizsa Stream. It was not a novelty that the natural conditions of the valley were favourable for the defence. György Malakóczy, the Captain of Bajcsavár, drew the committee’s attention to the fact that it had already been planned to lead water from the Mura River into the Kanizsa Stream through an old flood gate or ditch, which would be certainly a costly undertaking, but not unfeasible. It is also stated in this report that the effectiveness of the plan should be determined by someone who is an expert

5 *Domokos* 2012. 44–45.
6 *Geöcze* 1894. 647–678.
7 Baron Lazarus von Schwendi, German commander, Imperial General, Captain General of Kassa.

on the running of the watercourses.[8] The letter of the captain of the border defence system against Kanizsa also reveals that in autumn 1578, he also inspected the place together with György Zrínyi (IV), but because of the reeds and the water covering the area, they could not see much.[9]

The essence of the proposition is that the Mura is capable of transporting such an amount of water that can provide a constant water supply to the Kanizsa Stream through damming.[10] This helps swamping, maintains continuous water flow in the riverbed, makes travel difficult and slows down crossing. All these allow the defenders to gain time and move their forces to the right place. If it is done in time, they can attack the enemy during their crossing, which offers an enormous tactical advantage. This was well known, as the riverbanks were constantly watched and occupied when needed.[11] One of Zrínyi's famous military successes is also connected to such an event. On 27 November 1663, in a fight lasting a whole day, he defeated an Ottoman troop that attempted to cross the Mura. One of the components of the success, in this case, was again that the place of crossing was discovered in time, and thus, a large part of the attackers could be hit on in the water. "Suddenly, a shot by a minor mortar from an outpost signalled the appearance of the enemy […]. They became so frightened that they started to run towards the Mura and came face to face with the Tartars in the river. It resulted in such confusion that they were unable to swim, escape, or defend themselves."[12]

In this region, the water level of the Mura and the speed of the river was determinant when military operations were planned, whether they were offensive or defensive. We have data about several cases when Zrínyi's plans were influenced by the water level of the river. He wrote, for example, the following in one of his letters addressed to Ádám Batthyány: "…I do not know whether I will be able to attend the funeral or not, for in the autumn weather, the Mura has started to fall, and your Excellency knows well our state here that we cannot leave the Muraköz whenever we want to."[13]

The Ottomans were also aware of the dangers of the Mura and tried to prepare properly for each crossing. One of Zrínyi's letters makes reference to this, too: "…the Ottomans […] keep harrying us, as they did yesterday, trying to cross over to the Muraköz by leather vessels."[14] It took time – that is, preparation – to make such floating vessels. The cattle required for the leather bags needed to be skinned and their hides had to be sewn.

8 *Kelenik* 2012. 20.

9 *Kelenik* 2012. 21.

10 It is worth noting here that, in our reading, damming is the introduction of water into the river bed, while backfilling is increasing the water surface or water level by closing up an existing watercourse.

11 "There are nine outposts between Légrád and Kotoriba, which I have to maintain partly at my own expense and partly from royal pay. However, the money arrives so late and it is so little as if nothing came. So I cannot defend this line at my own expense any longer. The hill saves a lot of money for me because it substitutes six outposts, and although more soldiers will be needed here than at those six outposts, the soldiers are easier to support here because they are provided with vines, arable land and everything else they need." Miklós Zrínyi to the Imperial War Council. Légrád, 5 July 1661. See page 272 of the present volume.

12 ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 362, 761–762.

13 ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 610.

14 ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 238, 642.

Four such bags were tied to a wooden structure, which, when used as a ferry, was suitable for transporting up to 20–25 men.[15]

At another place he wrote the following: "The Mura is so shallow here that I do not remember when the Mura was so shallow in the last few years. As the Ottomans are assembling like this, I am especially vigilant, but I do not know from which direction to expect them."[16]

The Ottomans also knew that changes in the river's water level were crucially important for their success. Zrínyi wrote the following in August 1652: "Our only defensive bastion, the Mura, is now so shallow that even the infantry can cross it, and right now, as I am writing this letter, I receive the news that the Ottomans have arrived at the Mura seeking a ford, so I can expect guests tomorrow."[17]

Likewise, the occasional freezing of the river had also affected the military plans. "And the Mura has frozen so much that one can even tow cannons on it",[18] "…our Mura has frozen over, and we had to set out from our quarters, and only God knows what will be with us."[19]

The opportunities offered by the river were also decisive during the siege of Zrínyi-Újvár in 1664: "On 20 June, [*the*] defence of the Mura was [*re*]organised. A stretch of the river was assigned to each unit, and they had to defend them with trenches and guards, namely

1. the area from the confluence of the Mura and the Drava to the fortress belonged to the imperial army;
2. the area from the fortress to Kotoriba belonged to the League;
3. above Kotoriba, there was Count Zrínyi, as well as the *Hajdús* of Nádasdy and Batthyány."[20]

Anyone familiar with the area between the Mura River and the Kanizsa Stream (today's Principális [Main] Canal) – in the administrative district of Murakeresztúr – knows that linking the two watercourses required considerable expertise. The slope of the terrain is uneven, thus in the sixteenth and seventeenth centuries, the estimation of the amount of earthwork needed to lead the water of the Mura to the Kanizsa Stream whether there was enough water for it at all was only possible through experience.

This plan could be proposed only by a local, someone who was very familiar with this region and knew the relation and water regime of the Mura and Kanizsa Stream. Not surprisingly, it was Miklós Zrínyi, who – several years after his grandfather's inspecting the place in 1578 – had to put into effect this long-cherished plan in 1662.

[15] *Ludovika Akadémia Közlönye* [The Official Journal of the Ludovica Academy], 1891. II. 1277, minor publications (M. W.).
[16] ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 123, 553.
[17] ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 197, 607.
[18] ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 21, 475.
[19] ZMÖM 2003. Zrínyi Miklós levelei [Letters by Miklós Zrínyi] 121, 552.
[20] Raimondo Montecuccoli: Relazione della campagna dell' Armata Cesarea nell' Anno MDCLXIV. See page 296 of the present volume.

The characteristics of the Mura and the Kanizsa Stream

It is worth saying a few words about the watercourses in question. The Mura River originates in the Hohe Tauern Mountains in Austria, at an altitude of 1,764 metres. Its total length is 454 kilometres, of which only the lowest section (48 kilometres) – in fact, only its left bank – is found in the territory of Hungary. Yet, even at this lower section, it flows fast enough to change its bed in the loose soil continuously. Its valley is full of watercourses and backwaters. Sometimes the river breaks through its overgrown bends. The water level fluctuation of the Mura is little compared to other rivers. One of the reasons for this is that the snow cover in the Alps serves as a natural reservoir, which starts to thaw only when the floods caused by the spring rains are over. It is also typical of the river that it overflows quickly and recedes slowly. It takes 6–8 times longer for the river to recede than to rise. It changes its bed after almost every major flood, and there is hardly any place in its valley that would never have become a Mura bed. Its gravel sediment is covered with alluvial soils of varying thicknesses. Every type of these soils can be found here.[21]

The speed of the river water – that is, the speed measured in the streamline of the river, 30–40 centimetres below the water level – is most important from the aspect of our study. The velocity of the current depends on the gradient of the slope, the cross-section of the riverbed, the soil, as well as the depth and amount of water.[22] The streamline is not constant; it can vary and may show vast differences in a given cross-section, too.[23] According to the scholarly literature, the velocity of the current is considered slow to 0.5 m/s, medium to 1 m/s, fast to 2 m/s and very fast above 2 m/s.

Our measurements performed in the field – which are in agreement with the data of the scholarly literature – show that the speed of the river water in the streamline can reach, and in some places even exceeds 2 m/s, which means a speed above 7 km/h. At this speed, the crossing is a considerable challenge, whether on horseback, swimming, or on a human-powered floating vessel. Above 2.7 m/s, the crossing – on horseback, on foot, or by boats – is unpredictable; the current practically sweeps away everyone who tries it. [24] Crossing rivers of very high speed is not easy even in winter. On the one hand, they do not freeze easily; and on the other, the ice must reach a given thickness in order to be used safely. When crossing the frozen river, the thickness of the ice needs to be everywhere 16 cm for wagons, at least 15 cm for the cavalry and at least 9 cm for the infantry.[25]

Based on the above, crossing the Mura was a significant challenge. The time spent in the water increased, and it was difficult to predict where one would reach the other bank of the river. At this speed of river water, a swimmer can swim 10 metres in a minute, while a boat can travel with a speed of 3 to 50 metres per minute.

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[21] A Víz Keretirányelv hazai megvalósítása. Vízgyűjtő-gazdálkodási Terv 3-1 Mura. [National Implementation of the Water Framework Directive. River Basin Management Plan 3-1 Mura.] Published by the Central Directorate for Water and Environment, West-Transdanubian Directorate for Environment and Water, April 2010. http://vpf.vizugy.hu/uploads/ddvizig/projekt/lezarult-fejlesztesek/ovf-es-kozos-projektek/mura_vizgyujtogazdalkodasi_terve.pdf (Accessed: 12 December 2015.)

[22] The fall of the river is the difference in the height of the water level over one kilometre.

[23] Vízenjárási utasítás [Water Transportation Instruction] 1958. 16.

[24] Búvár utasítás [Diving Instruction] 1955. 6.

[25] Módszertani segédlet [Methodology Guide] 1955. 325.

The situation is further aggravated by the uneven current of the river, and the limited number of stretches suitable for crossing. It is easy to see that these circumstances were favourable for the defenders on the riverbank, which was known and taken advantage of by both Zrínyi and the Ottomans.

An important tributary of the Mura is the Principális Canal. Its catchment area is 609 km^2 and it is 57.1 km long. It flows from north to the south and has a narrow catchment area widening at the southern end. In the 1730s, Mátyás Bél wrote the following about the Kanizsa Stream: "It forms the border of our county with Somogy. It rises below the vine-growing Bogláts Hill, then flows along Szentmiklós and merges with the Mura beyond Zerin Újvár." Today's watercourse of the Principális Canal – due to the topographic features of the investigated area – follows the line of the former Kanizsa Stream. This is also evidenced by the maps of the military surveys, on which the course of the river can be easily followed.[26]

Before looking at the barrier capacity of the Kanizsa Stream, it is worth reviewing some indicators of fording capability. The wadeability of rivers and lakes depends on their width, depth, quality of the bed, the velocity of the current, the characteristics of the banks (height, gradient, wateriness and vegetation), as well as accessibility. Under favourable bottom conditions, up to 2 m/s current velocity, the barrier can be waded across to a depth of 1 metre on foot and a depth of 1.2 metres on horseback.[27] The passability of marshes is not constant. It depends on the quality and condition of the soil surface layer, and the amount of water in the soil.

We have little data about the Kanizsa Stream at this time. Contemporary depictions show that the valley of the stream – not so much because of the volume of water but rather because of its waterlogged character – had a great restraining effect. The left bank of the stream is a high bank between Kollátszeg and Zrínyi-Újvár, which has a height difference of 10–15 metres at some places. The right bank rises only slightly from the surface of the land stretching to the Mura – that is, the flood area of the Mura. Accordingly, the frequent floods of the Mura regularly reached even the Kanizsa Stream in this section. The backwaters and oxbows of the Mura are still visible in the immediate vicinity of the Kanizsa Stream. The Kanizsa Stream can be up to 2–4 metres deep and 10–12 metres wide.

The role of the Zrínyi Ditch and identifying its location

Modern warfare still uses the concept of a technical barrier system, one element of which is the technical barrier node. The latter is such a combined barrier that is created in harmony with the natural obstacles of the terrain to close down important routes, and it is always kept under fire.

In our case, Zrínyi-Újvár and the associated artificial and natural barriers can also be considered a technical barrier node, the purpose of which was to guard the crossing of the Mura that was important from both commercial and military aspects. The obstacles included the stronghold itself, the redoute built on the other bank of the Mura, the man-made fishpond, the outposts erected along the Mura, as well as the ditch linking the Mura

26 Historical Maps of the Habsburg Empire. http://mapire.eu/hu/ (Accessed: 14 October 2019.)

27 Műszaki utasítás [Technical Instruction] 1954. 338.

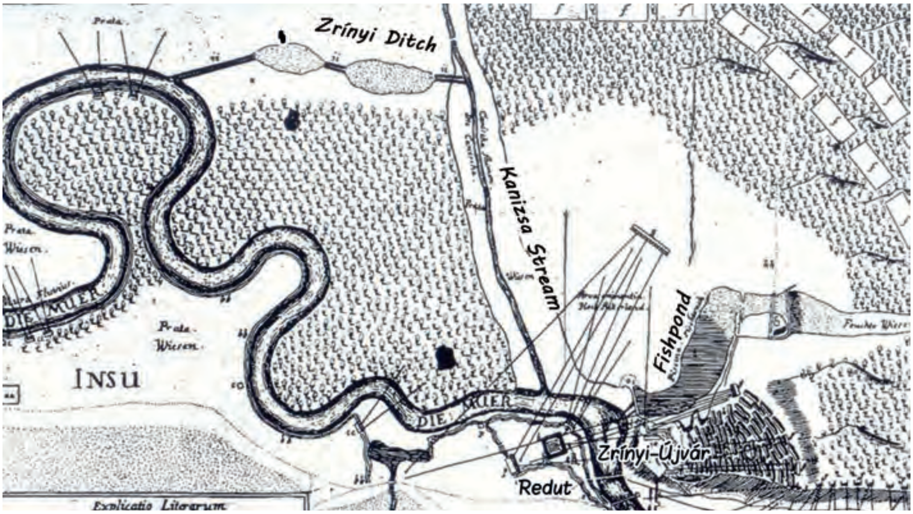

Figure 1.
The depiction by Holst
Source: Johann Martin Lerch: Zrínyi-Újvár and Its Surroundings at the Time of the 1664 Siege. Copy of the drawing by Jacob von Holst, imperial military engineer. Copper engraving. (*Szalai–Szántai* II. 2006. Plate 217. The texts of the figure translated into English for this volume.)

and the Kanizsa Stream.[28] The latter appears on the drawing by Holst – in the upper left of the image as a ditch connecting the Mura and the Kanizsa Stream *(Figure 1)* – and is mentioned by István Vitnyédy in a letter: "I arrived here rather late today, and heard about lots of things that happened since I had left. God grant that may end well. Our lord is in good health, and all his thinking is how to do harm to the Ottomans. He has recently had a great ditch dug at Ujvár, with the help of which the water of the Mura is led into the Kanizsa. This ditch and the great forest that has been buried will be for the benefit of the Ujvár. Over two thousand men were engaged in these works, all from the Muraköz."[29]

It is worth considering these lines and contemplating them, especially two statements. According to Vitnyédi, "he has recently had a great ditch dug at Ujvár". We know that the letter is dated 8 April, that is, the work was carried out in late March and early April.

[28] The ditch leading the water of the Mura into the Kanizsa (and thus raising its water level) was completed in April. István Vitnyédy to István Rabby, Locsmánd, 8 April 1662. *Fabó* XV. 1871. 195. This is shown on the sketches by Holst and by Esterházy: *„ff. Gräben, so der graff von Zrinmachenlassen den waldvor die guarnisonzuversichernvndzugebrauchen" Hrenkó* 1979. 127. The *Muster Comission* made up of war councillors and borderland captains (including György Zrínyi, Miklós Zrínyi's grandfather) made a proposal for raising the water level of the Kanizsa Stream with the water of the Mura at Kakonya as early as 1577, because, in their opinion, the Ottomans could easily cross it on horseback and on foot due to the low water level. *Kelenik* 2005a. 353; *Hausner–Négyesi–Papp* 2005. 836.

[29] Zrínyi had a large ditch dug at Zerinvár against the Ottomans: István Vitnyédy to István Rabby, Locsmánd, 8 April. 1662. *Fabó* XV. 1871. 195.

By this time, the incidentally frozen ground had thawed, and agricultural works started. The spring sowing began when the ground completely or partially ceased to be frozen, and no more permanent frosts were expected. It usually started on Saint Joseph's Day (19 March) and lasted to Saint George's Day (24 April), when maize sowing began.

The other statement goes like this: "Over two thousand men were engaged in these works, all from the Muraköz." The secondment of two thousand men seems to be a substantial number at first, especially in the light of the fact that that the population of Muraköz was around 32,000 at that time.[30] It means that – taking into account primarily the physically stronger male members of average families of five – one in three men was engaged in the construction of the ditch. In that season, they were supposed to work in the fields to lay the ground for next year's crop! This raises the question, what made Zrínyi take this hard decision, when, at the same time, 500–1,000 men worked at Zrínyi-Újvár every day.[31] He certainly did not have a large workforce, as we also have information that – in line with the decision of the Croatia's Sabor on 27 February 1662 – Varasd and Körös Counties also helped build the stronghold. "Each house (smoke) should provide two workers, equipped with axes and other tools, for the construction."[32] The fact that Zrínyi-Újvár and the Zrínyi Ditch were built at the same time suggests that the function of the two, namely the defence of the Mura crossing, cannot be separated from each other. This is evidenced by the simultaneous secondment of a considerable workforce.[33]

What was so urgent for Zrínyi then? In our opinion, the answer lies with changes in the water level of the Mura. The water level of the river has two peaks: a primary one in May and June and a secondary one in November. Accordingly, the objective was that the ditch completed by the spring floods should be filled with the rising water level during the spring floods. So the discrepancy between the frozen ground, the floods and agricultural works had been resolved by Zrínyi in this way.

The quotation from Vitnyédy clearly shows that the ditch led the water of the Mura into the Kanizsa Stream. The question is how the inclination of the terrain affected the shape and depth of the ditch. Looking at the map, it is difficult to tell the lateral inclination angle of the terrain between the Mura and Kanizsa Stream. Based on cartographic data, there is no significant difference between the water levels of the Mura and Kanizsa Stream, less than three kilometres from their confluence. This is confirmed by the fact that most of the village of Kollátszeg is found within a 131.25-metre high contour line, so the terrain has no dominant slope in any direction. On a map sheet from the 1970s, however, the water in the ditch is clearly shown flowing towards the Kanizsa Stream *(Figure 2).*

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30 *Végh* 2017. 265.

31 The construction of the fishpond near the fortress – which played a very important role in the defence of the fortress – alone involved the movement of more than 56,000 m^3 of earth, let alone the earthworks of the fortress.

32 *Kalsan* 2014. 109.

33 The population of Muraköz fluctuated between 18,000 and 32,000 in the seventeenth century. Within that, the population was the largest at the time of Miklós Zrínyi (1620–1664). The population density in the Muraköz was 30–40 people/km^2, whereas the average population in the Kingdom of Hungary was 15 people/km^2. *Végh* 2017. 265.

Figure 2.

Map sheet showing the flow direction of water in the ditch

Source: compiled by the authors

A hydrological survey conducted in 1915 reveals an even more intriguing situation. The survey indicates that there is less than seventy centimetres of difference between the two watercourses, towards the Mura. Nevertheless, it shows an uneven slope. According to the survey, the ditch – labelled as the Kollátszeg Canal – descends from the bridge on the Murakeresztúr–Kollátszeg road in both directions (the vicinity of the bridge being the highest point of the canal). It is easy to see why the designing engineer proposed a significant deepening of the canal. In this case, the goal of the deepening was to facilitate the drainage of the area.

The question is how much work the digging of the ditch reported by Vitnyédi needed under such slope conditions. We know from his description that Zrínyi commanded over 2,000 men from Muraköz to work on the ditch. According to the calculation of military regulations, the standard of land extraction is 0.3 m^3/h by hand; that is, assuming that everyone works at the same time, 600 m^3 of earth can be moved by such a workforce every hour.

We do not know the size of the ditch dug on Zrínyi's order. So based on the data available to us, we can say the following. The dimensions of the ditch – on the basis of the map from 1970 and calculating with a slope of 45° – were as follows:

- distance measured along the slope edge: 3.5 metres
- depth of the ditch bottom: 1.3 metres

From the above, it can be calculated that the amount of soil to be excavated was 2.86 m^3 per running metre. The length of the ditch – measured on the map – is 1,410 metres, so the total amount of soil to be excavated was 4,032 m^3. This means that the ditch depicted in 1970 should have been made by 2,000 men in nearly 7 hours.

Seeing this ditch in the terrain, it is clear that the restraining power was not represented by the ditch itself, but by the swamping associated with the ditch as well as the dense, impenetrable vegetation. It is also evident that the ditch needed have at least the same dimensions as the Kanizsa Stream itself (which was 12 metres wide by 4 metres deep) to be able to supply the stream with water incessantly. Calculating in this way, we get a higher number: 32 m^3 per running metre, that is, 45,120 m^3 along the total length. Under the given circumstances and conditions – i.e. 2,000 men working simultaneously for 10 hours a day – it took 75 hours, that is, more than a week of tense work for the available workforce to dig the ditch *(Table 1).*

Table 1.

The sections to be dug, their length and the quantity of soil to be extracted

	The length of sections and the quantity of soil to be extracted in each section
Section 1 Western ditch	460 m
	14,720 m^3
Section 2 Western oxbow	240 m
	7,680 m^3
Section 3 Middle ditch	160 m
	5,120 m^3
Section 4 Eastern oxbow	340 m
	10,880 m^3
Section 5 Eastern ditch	210 m
	6,720 m^3
Total	1,410 m
	45,120 m^3

Source: compiled by the authors

The table above includes information about works on the three connecting canals (sections 1, 3 and 5 from the Mura towards the Kanizsa Stream), and extraction works on the oxbows (sections 2 and 4). *Figure 3* shows the course and sections of the ditch.

Let us not forget, however, that the water flowing in the Mura was of much larger mass and velocity than in the Kanizsa Stream.[34] Consequently, the water – if the ditch is connected to it at the right place and in the right angle – entered the ditch with considerable force due to its mass and speed. The junction shown in the contemporary representation seems to be ideal from this point of view.

The next question to answer is where the ditch originated and where it led to. Based on maps available to us, we cannot define the seventeenth-century course of the Mura riverbed with absolute accuracy. It is visible on the maps that the river constantly changed its course, creating new bends and oxbows. Later, human intervention also became significant, as the settlement of Kollátszeg was built out, and in the nineteenth century, the railway line was

[34] This extent of the difference can be best illustrated by comparing the volume of water transported. At 4:00 a.m., on 21 October 2016, the Mura at Letenye delivered 208 m^3 of water, while the Principális Canal at Nagykanizsa delivered 1 m^3 of water per second.

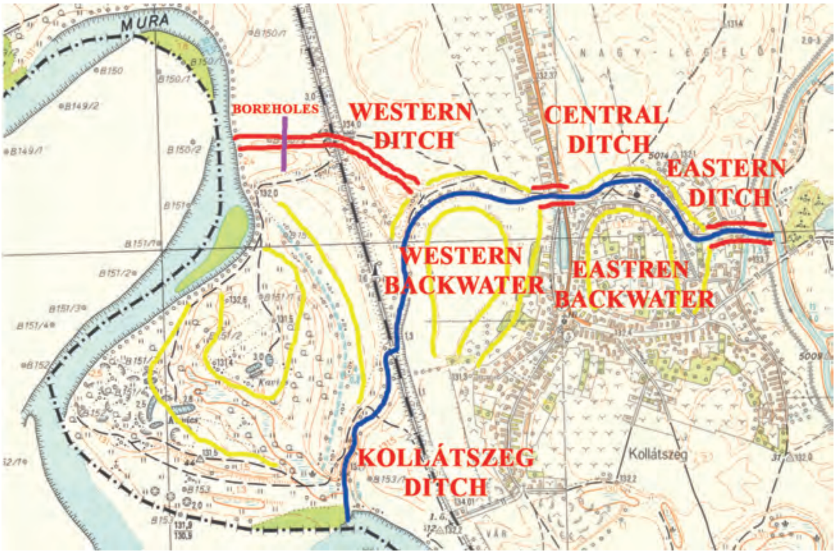

Figure 3.
The sections of the Zrínyi Ditch

Source: map made by the authors

also constructed.[35] The latter interventions set a limit to the channel migration of the Mura. The channel migration of the Mura can be described as follows.[36]

The first period of our investigation covers the sixteenth and seventeenth centuries, which is characterised by interventions protecting local interests. Unfortunately, we do not have any reliable maps from this period. The 1788 map and the surviving written documents reveal that these alterations did not affect the course of the riverbed, but were directly concerned with the protection of the banks. Due to the lack of organisation, the river could not be cut through. The first records about regulation works of the Mura date back to the second half of the eighteenth century. At that time, the alterations were limited to the protection of estates along the Mura and were carried out locally.

The second phase – in the era of the Austro–Hungarian Monarchy – saw larger-scale, coordinated work aimed at ensuring the navigability of the river. At that time, however, provincial conflicts made it difficult to implement the plans, and thus only a few cut-offs were carried out during a period of forty to fifty years. For the section of the Mura between Hungary and Styria, the first known regulation plan was completed in 1865. Thereafter, regulations were mostly restricted to the territory of Austria. It was not until 1897 that regulations started in Hungary. The aim of these was to create a unified riverbed with stabilised banks, to lower the water level, as well as to block and fill up the branches. According to the general principles

35 The railway line between Barcs and Gyékényes was put into operation on 1 September 1868 as part of the 72-kilometre long railway line of the Southern Railway Company connecting Barcs and Murakeresztúr. The state of the railway line is still affected by changes in the riverbed of the Mura. *Kovács* 1996. 124.

36 *Engi et al.* 2016.

of the riverbed, the radius of the smallest meander of the river had to be over 600 metres, and the width was also determined. Accordingly, the width of the riverbed had to be 100 metres from the Drava junction to the influx of the Kerka. From there to Ráckanizsa, it had to be 90 metres, and from there to Radkersburg, it had to be 75 metres wide. After 1918, the Mura became a frontier river from the Drava junction to the influx of the Kerka Stream. The regular regulation works on the part of Hungary were discontinued for a long time and served only to secure the banks and prevent excessive meandering.

The third phase, beginning with World War I, saw the most considerable change. Until then, four independent states shared the territory of the river under the control of one empire. After World War I, fundamental alterations were made on the left bank of the Mura (on the Hungarian side). In 1927, cut-offs were made at Muraszemenye, in protection of the Alsószemenye part of the settlement. In the area of Murarátka, the danger to the road was eliminated after the meander bend in the river was protected from bursting. In 1939, in the region of Letenye, shoreline defences, spurs and river closures were made in order to direct the streamline of the river towards the bridge of the public road at a favourable angle. In the area of Tótszerdahely, Molnári and Murakeresztúr, shoreline defences and regulation works were made. It was, however, only in 1940 and 1941 that flood prevention embankments (summer embankments) started to be constructed for the defence of smaller areas along the Mura. After 1950, the regionally competent Water Management Directorate took over the development and maintenance of defences built locally until then. The tendency was to integrate local interventions into a general water management plan that was completed in 1978. Nevertheless, only some of the planned riverbed protection and regulation works were carried out, and no riverbed cross-cuts were made. Based on the Austrian, Yugoslavian and Hungarian hydrological and hydrographic studies, the 1959 development programme determined the water yield of floods at 1,650 m^3/s and the distance between the embankments at 600–750 metres, and also defined the dimensions of flood prevention embankments. Initially, the defences were constructed after the surface profile belonging to water level +500 cm measured by the water level gauge at Letenye. At the time of the 1972 flood, the water level gauge at Letenye showed that the water level peak was at +514 cm, which was later regarded as the standard water level. During that flood, the embankments burst at two locations (at the Tótszerdahely and Birkitó river loops), causing significant damage. After 1972, the embankments were developed in several loops. The modern defences (flood embankments and structures) were constructed in several stages between 1965 and 2015.

For mapping the Mura riverbed in Zrínyi's age, it is worth beginning with the interpretation of the earliest representations. The earliest such representation comes from 1794, which shows the Mura between Kollátszeg and Kakonya *(Figure 4).* In this image, one can clearly identify the meanders known from the drawing by Holst, but there is no trace of the ditch in question.

The First Military Survey also shows the examined section of the Mura and distinctly depicts its oxbow and the ditch linked to it *(Figure 5).* The other end of the ditch is clearly connected to the Kanizsa Stream. It is worth noting here that there is no other ditch between Murakeresztúr and Kakonya connecting the two rivers. There is one more important point of orientation on the road from Murakeresztúr, namely the bridge above the ditch in the vicinity of Kollátszeg.

Figure 4.
The region of Kollátszeg in 1794
Source: https://maps.hungaricana.hu/hu/OSZKTerkeptar/789/
(Accessed: 25 November 2017.)

Figure 5.
The results of the First Military Survey
Source: http://mapire.eu/hu/map/firstsurvey/?layers=osm%2C1%2C73&bbox
(Accessed: 20 November 2017.)

The next drawing worth observing comes from 1816. This shows the investigated section of the riverbed with the same course as the map from 1794 *(Figure 6).* This already depicts those interventions that are indicative of the planned cross-cuts and river bend cut-offs. What is really interesting to us, though, is that it depicts the completely cut-off oxbow lake and (in its bend) the ditch in question next to Kollátszeg.

The 1855 cadastral map depicts the waterbed of the oxbow lake filled with water and the ditch linking it with the Kanizsa Stream *(Figure 7).* On it, one can again identify the bridge and several breakpoints of the ditch that is still visible today.

The Third Military Survey (1869–1887) markedly shows the ditch and its dimensions, and it demonstrates the fact that today's Kollátszeg developed on the inner side of the cut-off riverbed *(Figure 8).*

An aerial photograph taken in 1960 clearly shows both the cut-offs and the structure of the Kollátszeg settlement *(Figure 9).* In the aerial photograph, one can distinguish well the former riverbed of the Mura, two natural riverbeds very close to each other, as well as the man-made ditches and canals.

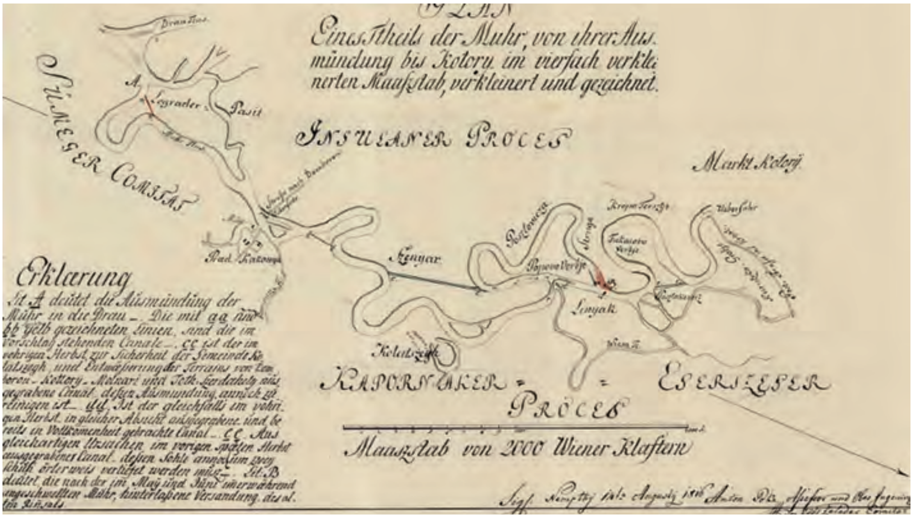

Figure 6.

Kollátszeg in 1816

Source: https://maps.hungaricana.hu/hu/MOLTerkeptar/5502/view/?bbox=-492%2C-3091%2C5596%2C-315 (Accessed: 1 December 2017.)

Figure 7.
The investigated area in 1855
Source: https://maps.hungaricana.hu/hu/MOLTerkeptar/19000/view/?pg=3&bbox=-707%2C-6800%2C9270%2C-194 (Accessed: 1 December 2017.)

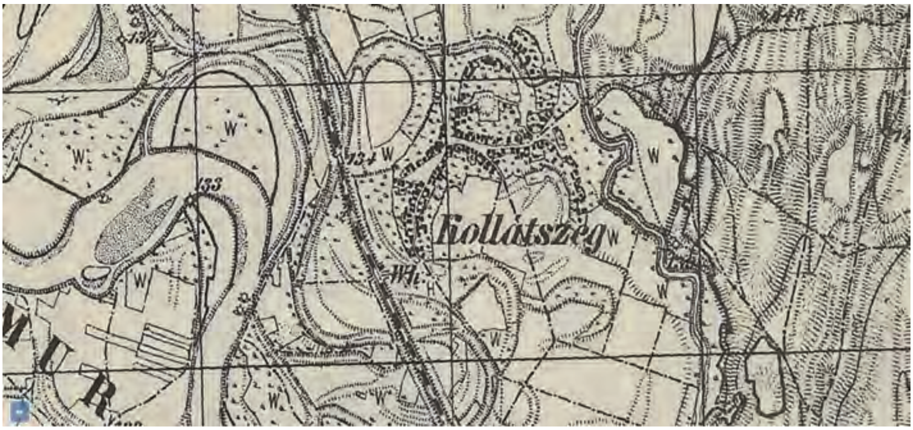

Figure 8.
The results of the Third Military Survey
Source: http://mapire.eu/hu/map/hkf_75e/?layers=osm%2C8&bbox=1865264.737865862 (Accessed: 2 December 2017.)

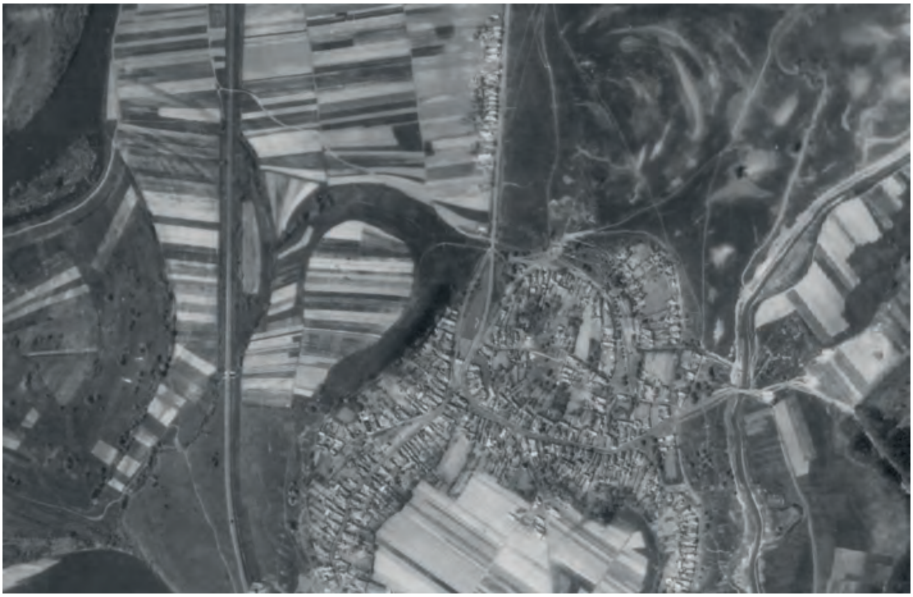

Figure 9.
Aerial photograph from 1960
Source: Ministry of Defence, Institute and Museum of Military History

The possibility of a field survey

Observing the morphology of Murakeresztúr – and within it, that of Kollátszeg –, we can see that the houses are predominantly located along the roads, which run in the higher parts of the settlement. This is typical of settlements built in areas endangered by floods. The terrace on the right bank of the Principális Canal can be identified with the former high bank of the Mura, while the flat area to the west of it has been filled up by the sediment of the river. Due to relatively high water flow rates, the varying rates of water discharge, and high amounts of sediment, the river often changes its course. However, the location of the village suggests that there were higher-lying areas in the potential floodplain that were certainly bypassed by the river, and were inundated only at times of great floods. The northern part of Murakeresztúr is found next to an east–west road. From the western end of this part of the settlement, an approximately one-kilometre-long north–south road led to Kollátszeg. This road runs on the edge of an elevated area stretching westwards to the Mura. On this relatively even land surface, we cannot see any traces of the former riverbeds, while at Kollátszeg there are three oxbows in a row, along a nearly east–west axis. Since the river was unable to hollow the hard surface of the elevation lying in the north, it made a loop eastwards in the lower-lying land area and filled it up over time. Afterwards, it moved towards west, made another loop, filled the land up at times of great floods, and moved further to the west again. The northern extension of the loops was delimited by the edge of the elevated area. Based on the relief of the ground surface, we can say that from the direction of Zrínyi-Újvár, Kollátszeg was the most remote point offering favourable conditions for interlinking the Mura and the Kanizsa Stream. Increasing the water level of the stream with water directed into it from the Mura was only one of the factors to be considered when defining the right place for constructing the Zrínyi Ditch. However, it was at least as important to occupy the forest stretching between the two watercourses and to prevent its accessibility from the north with the ditch. The current ditch connecting the Mura and the Principális Canal runs below the edge of the elevation lying in the north, which indicates that the builder tried to push the canal as far north as possible. The western part of the ditch follows the bed of the former backwater, and, turning southwards, it flows into the Mura.

The Zrínyi Ditch depicted by military engineer Holst is similar to the Kollátszeg Canal in terms of its structure. However, it is questionable whether we can tell 350 years later that a canal dug in 1662 and used for its original purpose for merely two years could leave a trace in the land remaining to this day. All the more so because, its original function was to close off the forest to the Ottomans, so there was no reason to maintain it after 1664. When Zrínyi-Újvár was destroyed, the ditch was also doomed to be filled up. Nevertheless, there are also arguments for its survival. The bed and dam of the fishpond on the eastern side of Zrínyi-Újvár are still recognisable, and the Principális Canal (Kanizsa Steam) runs in the former river bed of the Mura. All in all, we can say that a field survey can be fruitful if we know what we are looking for and where we are.

Our previous research has demonstrated that, in his sketch, military engineer Holst not only depicted the features roughly but tried to represent them in his drawing as accurately as possible. Those features, in fact, are shown in that way in his drawing because they looked like that in reality. In the present case, we can reasonably assume that he did not invent the existence of a ditch somewhere between the Mura and Kanizsa Stream, but he drew exactly what that waterworks looked like. By identifying the location of the ditch, we not only identify another structure connected to Zrínyi's activities, but we also test the authenticity of the sketch made by Holst. The accuracy of the depiction of the Zrínyi Ditch is important from a source-critical point of view, because it is far from the fortress and did not have any role in the siege, so it would even be acceptable if it had been depicted with certain inaccuracies. Was military engineer Holst really so meticulous that, even in this case, he insisted on an accurate representation insofar as possible?

The sketch shows that two irregular elliptical patches found between the Mura and Kanizsa Steam are connected by three straight lines to the Mura and Kanizsa Stream. It is not difficult to interpret the lines: these are the ditches. However, the irregularity of the patches may indicate that those are not man-made features. The Kollátszeg Canal connecting two cut-off backwaters shows this structure. The eastern and western backwaters are interconnected by the central channel. The eastern backwater is joined by the eastern channel with the Principális Canal, whereas the western backwater is joined by the western channel with the Mura. From the three channels, the western one is the longest. Following Zrínyi's line of thought, the two watercourses needed to be connected at a place where they were the closest to each other, and for this, the existing backwaters also needed to be used. At Kollátszeg, there were two backwaters next to each other, which saved a lot of labour, workforce and time. It is highly likely that the military engineer sketch probably represents the Kollátszeg ditch. Nevertheless, the current position of the channel connecting the western backwater with the Mura significantly differs from the one on the representation. We can see that this part of the Kollátszeg Canal turns sharply southwards from the western backwater, while the western ditch depicted by Holst runs to the river keeping its approximately east–west direction. One of the most important aims of the field research was to decide whether the western ditch led across the area to the west of the western backwater (the way Holst depicted it), or was the representation inaccurate? An argument for the representation by Holst may be that it was logical (though, not from hydrological considerations) for the ditch to join the upper part of the river bend, because, in this way, the current made the water run into the channel. Accordingly, the western channel should be sought somewhere to the north-west of the western backwater, where currently there is a relatively flat arable land. Yet, the edge of the higher-lying area to the north is well recognisable here as well.

During our first field survey, we observed a recess in the north-western wall of the western backwater, which (after closer examination) was identified by some members of the group as the joint of the former western channel, while others regarded it as the cutting of an access road. Although some wheel ruts were visible, indeed, we could not exclude the possibility that it being a ramp was only a secondary and later use, and originally it was the joint of the western channel. A 1:10,000 scale map of the territory and aerial photographs indicate a trench between the cutting and the Mura. In the field, under favourable conditions, one can see a longitudinal depression in the ploughland under the edge of the higher-lying ground. We would be able to investigate whether this is a ditch by digging one or more test trenches across it, hoping that the section wall reveals traces of the ditch. As we did not have a possibility to do it, we drilled holes along a fifty-metre straight line (see *Figure 3*) and tried to infer the structure of the soil from the extracted soil samples.

The drilling of the holes along a roughly north–south line was started at the distinctive high bank in the north. Heading southwards, we took samples from the deeper-lying section of the presumed ditch, as well as from its presumed southern bank. The top layer of soil is formed by sandy soil everywhere, which had a depth of ca. 50 cm at the top of the high bank in the north, and increased up to 100 cm in the ditch. Underneath, there is a heavily cohesive, impervious layer of clay. We took a sample from this at one place in the area of the ditch and found blue clay under it. The depth of the impervious layer proves that the ditch-like depression that is also perceptible on the surface truly indicates an approximately one metre deeper ditch. The edge of the southern side could not be identified well because of the erosive effect of the Mura. Nevertheless, the two samples taken five metres apart from the bottom of the ditch revealed that below the 100 cm deep soil layer, there was a layer of loose, yellowish river sand in a thickness of 5–10 cm, above the impervious layer. This suggests that water was constantly moving in a narrow stretch of the area – in other words, the water was flowing in the canal – but it stopped after a while, and the ditch was filled up.

Regarding its history, the ditch served its original function for two years, and during that period, it was most likely to be maintained continuously. Due to its position, the erosive effect mainly took place on the southern side of the ditch, and after its maintenance was terminated after 1664, the water kept pulling down its southern bank in the direction of the western backwater, resulting in a periodic lowland overflow.

As the description of investigations in the field demonstrates, the analysis of micro-morphology plays an important role in identifying the line of the ditch. The largest scale map (1:10,000) available to us shows a 0.5-metre difference of level. We need a higher definition than that. That is why, at the beginning of the research, we decided to carry out a LIDAR (Light Detection and Ranging) surveying of the area, if we had the financial resources for that. The application of this method considerably helped our work during our investigation of Zrínyi-Újvár.[37] As a matter of fact, every field research where micro-morphological features may be significant should begin with LIDAR surveying. However, the sum of money that is required for this is rarely available at the start of the work. We received help in this from the West-Transdanubian Water Management Directorate that had previously surveyed the area with this method and provided us with their data set.[38] The assessed images clearly show the interventions made in the field. Based on this, we received further confirmation, which is demonstrated in *Figure 10.*

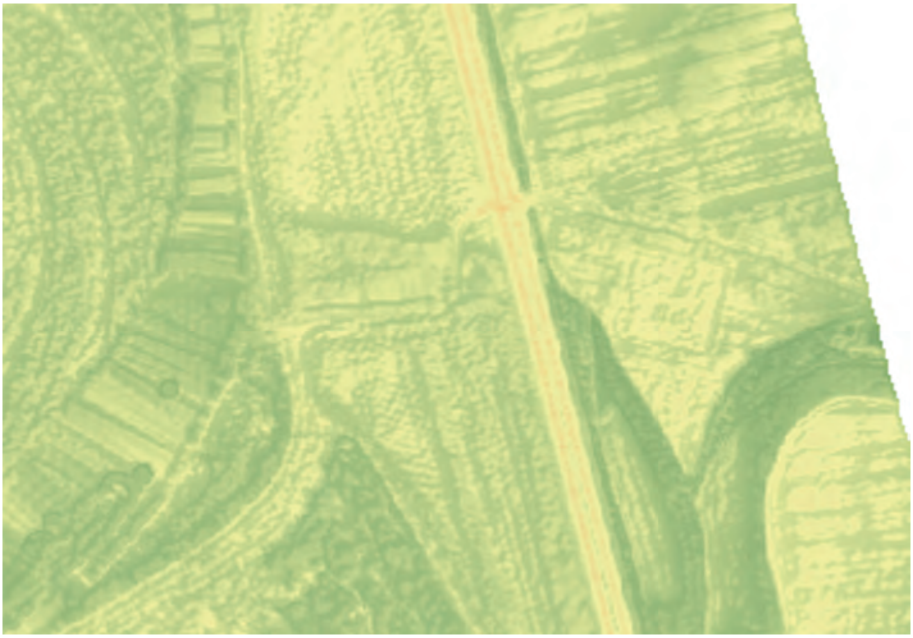

Figure 10.
Details of the Zrínyi Ditch identified on the LIDAR image
Source: West-Transdanubian Water Management Directorate

37 Airborne Laser Scanning (LIDAR) is an active remote sensing technology that can collect large amounts of remote sensing data over a very short period of time. One of the main advantages of LIDAR is that it is able to collect data from areas where ground-based geodesy surveying would require high resources. (See in detail: www.fataj.hu/2015/05/183/201505183_Erdo-taverzekeles.php [Accessed: 10 December 2017.]).

38 We would like to thank Dr. Zsuzsanna Engi, a certified civil engineer, Head of the Department of Water Management and Irrigation of the West-Transdanubian Water Management Directorate for her selfless support and professional help.

Magnetometer surveying[39]

In May 2018, a magnetometer survey was carried out in the area investigated with field surveys and soil drilling and sampling.[40] This method is highly suitable for observing man-made features – especially in areas that were not disturbed or were only slightly disturbed later – such as the ditches supposed to exist here. We used a Sensys MXPDA measuring instrument with Fluxgate gradiometer sensors. During the survey, the sensors were fifty centimetres from each other, and the distance between the measuring points was ten centimetres. The data were recorded with an accuracy of one to three centimetres, which were collected by JAVAD Triumph-1 receivers connected in a base/rover configuration.

The resulting image (depicted on a colour scale from –5 to 5 nT/m; *Figure 11*) shows a distinct, approximately 175-metre-long anomaly directed north-west–south-east suggestive of a ditch in the middle of the image. In the south-east, it was divided into two 85-metre-long branches running parallel to each other *(Figure 12).* The average width of its cross-section varies between five and nine metres. Its depth cannot be determined from the picture. The feature certainly continues beyond the survey area in both directions. Its north-western end must have been connected to the Mura flowing there in the past, but this could not be investigated due to the vegetation along its banks. In the south-eastern direction, it must have run towards and beyond the railway line. (In this latter case, however, it is questionable to what extent the subsequent earthworks, for example, in the vicinity of the railway line disturbed the ditch).

Based on the historical data detailed above, the topography of the area, as well as the results of on-site investigations (e.g. soil drilling), this anomaly can be identified with the former Zrínyi Ditch with great likelihood (and within that, with its north-western section closer to the Mura). At the same time, it is not clear whether the dual structure observed in the south-eastern part of the surveyed ditch can be considered the result of the original construction work in 1662, or that of later constructions. The former is also possible, but the latter is supported by the fact that the sketch by Holst mentioned above shows only one ditch. It is likely that a new ditch was dug next to the existing one (presumably with the purpose of drainage). An excavation could help to decide this and to clarify our data about the ditch(es). One or more cross-sections perpendicular to the ditches would provide important additional data.

[39] The report of the magnetometer surveying was made by László Nagy (archaeologist, Buda Castle Estate Development and Operation Nonprofit Ltd., Site Diagnostics Department).

[40] The survey was conducted by László Nagy and Ferenc Somogyi (archaeological technician, Buda Castle Estate Development and Operation Nonprofit Ltd., Site Diagnostics Department).

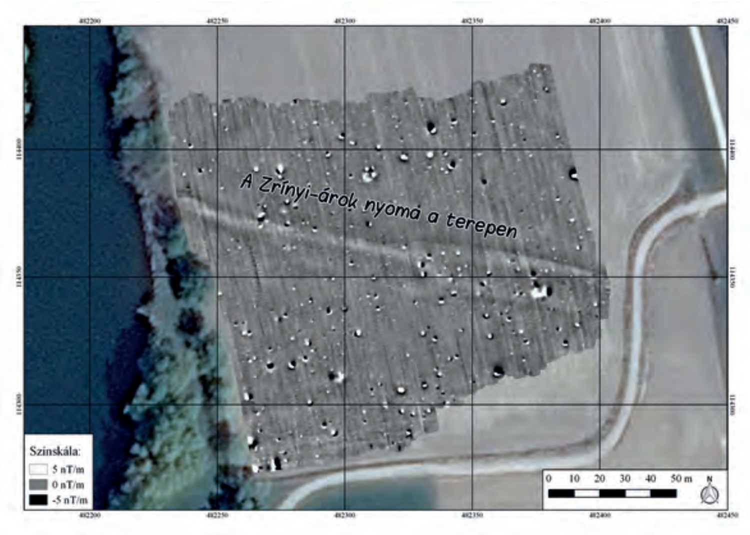

Figure 11.

The location of the magnetometer survey on the overview map of the area

Source: László Nagy archaeologist and Ferenc Somogyi archaeological technician, Buda Castle Estate Development and Operation Nonprofit Ltd., Site Diagnostics Department

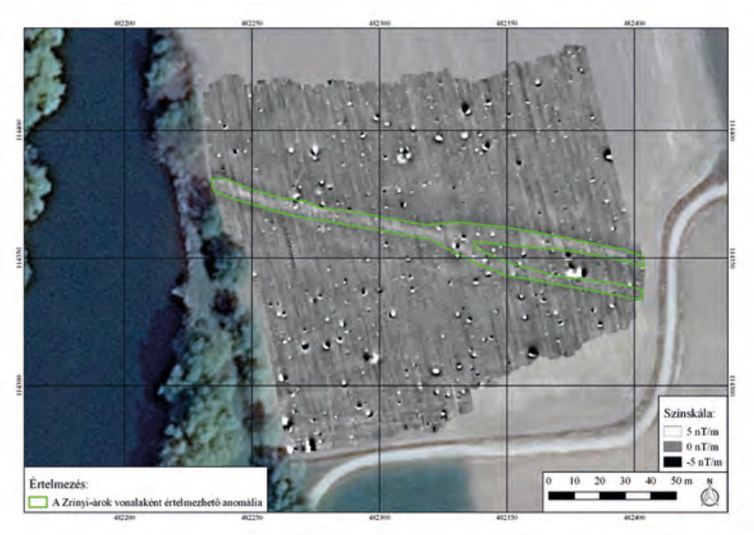

Figure 12.

The interpretation of the results of the magnetometer surveying (the green colour is used to highlight the anomaly interpreted as the remains of the Zrínyi Ditch)

Source: Pethe Mihály geophysicist, Buda Castle Estate Development and Operation Nonprofit Ltd., Site Diagnostics Department

Summary

Historical sources have preserved the memory of Miklós Zrínyi connecting the Mura and the Kanizsa Stream with a ditch in 1662. Engineer Holst depicted the ditch in a sketch, but it can also be observed that two catchment areas were also joined to the system. The analysis of the GIS material available from the area reveals the remains of the Zrínyi Ditch that still exists at Kollátszeg. Today, it still interlinks the river and the stream and crosses two adjacent backwaters, from which the one on the right can be recognised only after the street system of the settlement.

The current course of the ditch on the west differs from the one depicted by Holst military engineer. Our field survey showed that this section of the Zrínyi Ditch has been filled up by now, but there are still some recognisable traces of it in the morphology and micro-morphology of the area.

The significance of the research is that the ditch is the second construction in Hungary – after Zrínyi-Újvár – that is directly connected to the person of Miklós Zrínyi. This structure again proves that Zrínyi was far ahead of his time in this field, too. Recognising and using the potentials of the terrain to a high degree, he increased the effectiveness of defence protecting his beloved homeland.