Project plan for Vallkärrabäcken

Potential actions to improve recreational values and nutrient retention

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(photo: Ida Sekizovic)

Summary

By request from the municipality of Lund this report was written in order to investigate the south basin part and the mainstream part of Vallkärrabäcken. The small stream located north of Lund is highly affected by toxic substances and nutrients as its catchment area consist mainly of urban area and agriculture land. Vallkärrabäcken has also problems with large variation in stormwater runoff and erosion. For these reasons, the aim was to map the area and make a project plan for actions to improve recreational values and nutrient retention along the stream. The study was performed by following; a field manual for habitat mapping of watercourses, interviews with people visiting the area and finding solutions by studying available literature.

The report contains a lot of different recommended action for the area. In order to increase recreational values suggestions are presented such as making improvements for the existing walking path by increasing the maintenance and inserting more benches and at least one toilet. Regarding the nutrient retention the main suggestions turned out to be to construct a number of wetlands in the upstream part of the investigated area and to make some actions to handle the erosion problem along the whole stream *e.g.* by using bank shaping such as two-stage channel.

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1 Introduction

By order of the municipality of Lund this study investigated a specified part of Vallkärrabäcken, a small stream north of Lund. The aim was to map the area and make a project plan for actions to improve recreational values and nutrient retention along the stream. In recent years, restoration work has been carried out at some stages of Vallkärrabäcken, but more needs to be done in order to handle the high levels of toxic substances and nutrients in the water due to the stream's surroundings as it is close to the city and affected by agriculture. Problems have been described such as erosion, big variation in storm water flow from the nearby city and high concentrations of nitrogen and phosphorus. This report contains recommended actions for dealing with these aspects and what they might cost. Additionally, the report will point out uncertainties and reflections regarding the different proposed solutions. The suggestions for the area are based on the authors obtained knowledge together with an implemented habitat mapping, interviews with people that visited the area while the field investigation was performed and a literature study.

1.1 Vallkärrabäcken

Vallkärrabäcken is a stream that is a part of Önnerupsbäcken, a so called a tributary, which in turn is the river Höje å's biggest tributary and finally the water flows out to Öresund (Bydén, 2008; Höje å Vattenråd, n.d, b). Hence, Vallkärrabäcken belongs to Höje å catchment area and receives water mainly from the northern part of Lund. The upstream part of Vallkärrabäcken is divided into two parts; north and south, which then flow together and create the mainstream of Vallkärrabäcken, see Figure 1.1. The physicochemical and biological factors are distinctly different for the north and south part (Bydén, 2008; Höje å Vattenråd, n.d, a). As shown in the Figure 1.1, the catchment of the stream as a whole is depending on the catchment areas of Vallkärrabäckens northern part (mainly agriculture land) and Vallkärrabäckens southern part (mainly the north part of urban area in Lund). The projects specific section of Vallkärrabäcken (coordinates from 55.738895 °N and 13.173443 °E to 55.737718 °N and 13.148333 °E) does not include the northern part of the catchment area, The southern part will therefore have more focus in the following background to enlighten the problems in the stream which is of concern for this project. °

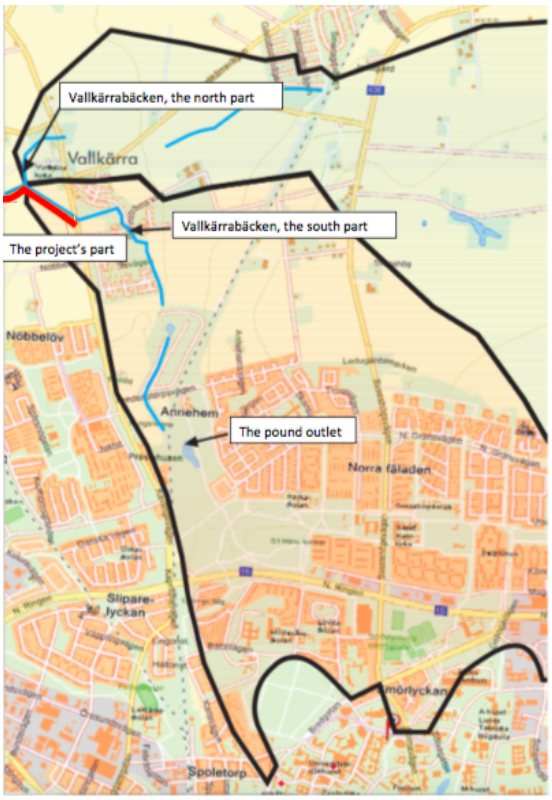

Fig. 1.1. A map of the divided catchment area of Vallkärrabäcken. The red line is the beginning for the project's part of the stream. The map is modified from Bydén (2008).

Within the project part of Vallkärrabäcken problems with deforming skeleton in trout (*Salmo Trutta*) has been detected since 1998 and along with a high nutrients overflow from agriculture (Borgström et al, 2008; Bydén, 2008). Both the deforming in fishes and over fertilization in the stream have been studied and it have resulted in two different sources and locations for these problems. In the south catchment part of Vallkärrabäcken, does the north urban part of Lund influence the stream the most, due to a recreation area called St Hans Backar which used to be Lund municipality's largest landfills until the late 1960s (Höje å Vattenråd, n.d, a). As precipitation penetrates the old dump the risk increases for contaminated leachate which can affect the water status in Vallkärrabäcken. This leakage from the dump site is the main cause for the deformation of fish in the south basin part of the catchment (Höje å Vattenråd, n.d, a). However, actions were made during the years 2013-2015 by the municipality of Lund and Lund public cleansing department, by placing sedimentation ponds for water treatment close to the landfill site as well as covered the landfill site with impermeable material such as clay, in order to avoid rain water from entering the contaminated landfill. Which results in less dispersion of hazardous substances and thereby improving the water status in Vallkärrabäcken (Höje å Vattenråd, n.d, a). Thus, results from previous action of restoration for fish habitats nearby and in our part of the stream, the deforming fish will not have a high priority in this project (Avfall Sverige 2009; Naturcentrum AB, 2008). The general conclusions from studies have been; deforming fish only exist in the stream affection from the south catchment area which further

depends on organic pollutants such polyaromatic hydrocarbons (PAH), PCB, HCB, DDT and dioxin (Borgström et al, 2008; Avfall Sverige, 2009). Some heavy metals are also contaminating the stream but is not causing the deformation in fish skeleton (Bydén & Wengström, 2008).

Although many ponds and wetlands have been constructed in the catchment area, the water status in Vallkärrabäcken is still classified as unsatisfactory due to the high nutrient content (Höje å Vattenråd, n.d, b). Nöbbelövs mosse which is located in the downstream part of Vallkärrabäcken was in 2014 classified as a nature reserve and with its all man-made wetlands it acts as a retention basin for the downstream part of Vallkärrabäcken, see Figure 1.2. In 2008 a number of efforts were made to make 600 meters long stretch of the stream better for trout as well as increasing the accessibility for outdoor activities in the area. The restoration work included *e.g* placement of boulders, stones and gravel in the water along the stretch to improve different habitats for trouts and reducing sharp edges in order to reduce the risk for erosion. Additionally, a pier was constructed close to the stream as a resting spot and viewpoint for visitors (Naturcentrum AB, 2008). The investigated part of Vallkärrabäcken is in total 1684 meters and can be seen in the map below, Figure 1.2. The stream is rather straight except for one turn from the south basin part to the mainstream (seen from the right in the map). The stream location is not distinctly different from a historical view, figure 1.2. Where the part of the stream being investigated in this report ends where the water is entering an underground culvert and flows additionally 800 meters before it reaches the municipality of Lomma (Höje å Vattenråd, n.d, b). The space classified as nature reserve and drainage area in the streams surroundings are also marked in the map.

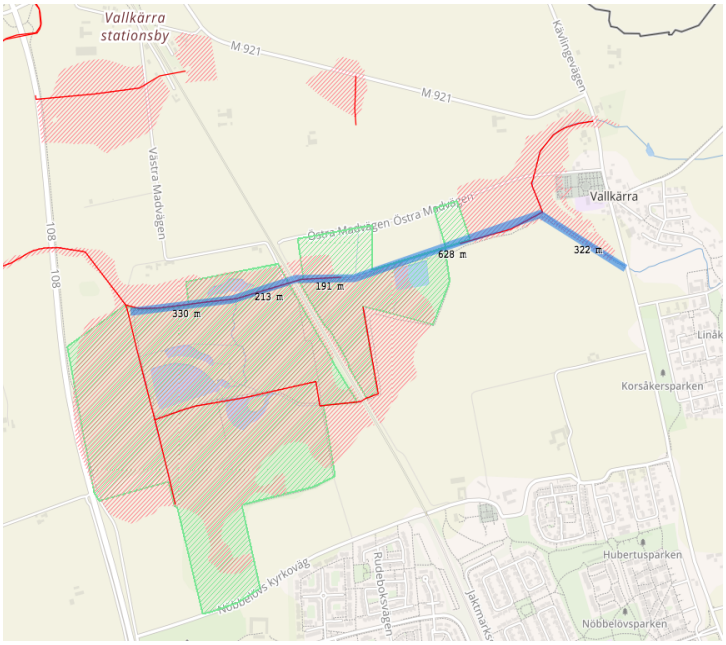

Fig. 1.2. A map of the investigated part of Vallkärrabäcken (blue bold line**)** with marked area classified as nature reserve (green crosshatch area) and former wet areas from 1800s (red crosshatch area) (VattenAtlas, 2018).

2 Method

The methods used for the assignment are described in this section.

2.1 Habitat mapping

To get an overview of the site, a mapping of the area was carried out by mainly using the standardized method habitat mapping. It is an important method for assessing an area's naturalness and physical impact and it can for example help determine the biological values, quantify habitats and discover threats against the investigated location. It is therefore a great tool that can aid decision makers to establish action plans. The method involves GIS, field mapping and data compiling. The first step was to create a map of the section of the stream to be analysed by using GIS. Remote sensing data was used to determine land use of the surroundings of Vallkärrabäcken and the credibility of the data was then checked during the second step, the field study. The field study was carried out May 21st by following a field manual for habitat mapping of watercourses (see report from the County Administrative Board of Jönköping, Meddelande 2002:55). The field manual consists in total of five parts (Protocol A-E):

Protocol A (the biotope within streams)
Protocol B (ambient habitats and the close surroundings of the watercourse)
Protocol C (inflowing tributaries and ditches)
Protocol D (barriers to fish migration in the stream)
Protocol E (road passages)

All parts were noted during the field study and the findings that were considered most important are presented in section 3.1.

2.2 Interviews with people visiting the area

An interview regarding potential increased recreation values was conducted during the field investigation with visitors in the area that crossed our path. The interview consisted of three questions, which are listed below:

-Are you often in this area?
-Which activities do you mostly perform here?
-Do you have any suggestions for improvements that you would benefit from?

2.3 Literature study

Together with obtained knowledge, a study of existing literature was performed in order to be able to present a project plan and proposed measures for the area. The main task of the literature study was to find details about the suggested actions and to examine its possible costs.

3 Results and discussion

This chapter present the main results from habitat mapping and the interviews.

3.1 Habitat mapping

The results from Protocol B, that describes ambient habitats and the close surrounding of the watercourse are presented in a map, Figure 3.1. The close surroundings consist mostly of open land and agricultural land and the stream is located near the urban area Vallkärra, section 6 in Figure 3.1. Passages from protocol E is mapped in Figure 3.1, where point E1 on the map indicates the location of a busy paved road and point E2 indicates a small gravel road. At point E2 is also where the nature reserve begins (green circle). Noticeable restoration of the stream was seen in the part that was located in section R2-R4, where recreational improvements were made as well, with informative signs about biodiversity. The previous restoration performed is described in the introduction.

The surrounding is as described in the introduction the main cause for the eutrophicated waterstream, and during the field investigation the overload of nutrients was clearly presented as the stream consisted of and was surrounded by high amounts of vegetation, see Figure 3.4. The stream itself was not visible during most sections due to the vegetation, invasive cow parsnip and steep edges around the stream, which hindered the team from approaching the waterstream at some sections and executing a thorough examination of the drainage pipes. The amount of drainage pipes that was observed might thus be far from the accurate number. Although, it was manageable to conduct width, depth and flow measurements of the stream as well as an sedimentation observation at three locations, presented in Table 3.1.

Table 3.1. Presented depth, width, velocity and sedimentation observation of the lake that was performed on the right side of the river in the flow direction.

Section	Depth (m)	Width (m)	River flow (m/s)	Sedimentation
R1	0,15	1,17	0,50	Sand and stone
R5	1,00	4,20	0,10	Clay
R6	0,02	1,00	0,10	Clay

The river flow and the shape of the river that was observed was almost consistent in all sections, hence only three observation section were needed. As one can see in Figure 3.1 the stream is straight through the whole studied stream section and yet Table 3.1 indicates a low water velocity and a low water depth. The reason for this might be that low amount of water was running in the stream during the field study, and that during precipitation the straight stream causes high velocity.

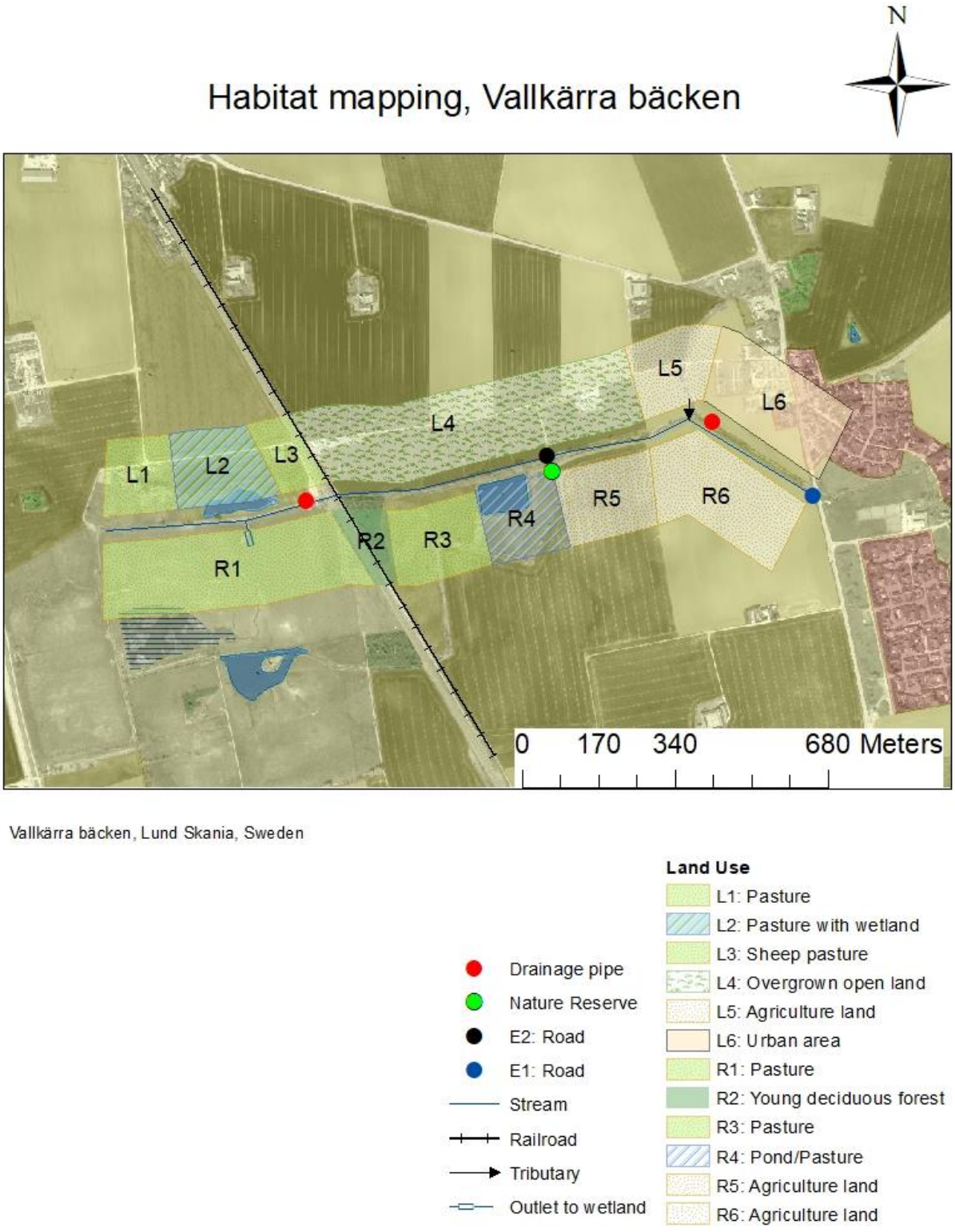

Fig. 3.1 Habitat mapping of the investigated part of Vallkärrabäcken.

3.2 Interviews

The three interviews that took place during the field study are summarized in Table 3.2.

Table 3.2 Summarized interview regarding restoration improvements in the catchment area.

Respondent	Are you often in this area?	Which activities do you mostly perform here?	Do you have any suggestions for improvements that you would benefit from
Preschool teacher	First time with the preschool children.	School outings.	Today I noticed that some toilets would be nice.There is toilet paper lying next to the wind shead and it doesn't look pleasant.
Older lady on a walk	Yes, I live nearby.	I often take long walks with friends.	I would like to see some benches where one can take a coffee break on sunny days. It would also be nice if the river was visible in some parts.
Middle age man	Yes, I live in a residential not far away.	Work out and walk.	Some sort of drainage on the passage under the railroad (Figure 3.3) would be nice. During winter it's impossible to cross it.

Fig. 3.2 The stream in section L6/R6.

Fig. 3.3. The railway underpass located in section R2.

Fig. 3.4 Drainage pipe to a wetland, marked in the habitat map.

4 Suggestions

Suggestions to increase recreational values and nutrient retention time are presented in the following chapter. In the following divisions for implementations, the suggestions concerning the recreational values are mainly focused from the field studie and the respondents answers in Table 3.2. There are some examples of economical fundings for the municipality in Lund to apply. And for nutrient reduction simplified cost calculation has been conducted.

4.1 Suggestions to improve recreational values

This section describes possible actions for improve recreational values along the stream.

The walking path

During the field study it was concluded that there is a nice grass walking path along Vallkärrabäcken as one reaches the nature reserve, see the red marked walking path in Figure 4.1. However, there is no walking path along the part of the stream which is not included in the nature reserve. Since the small road, marked with yellow in Figure 4.1, can be used as a walking path which leads to the center of Vallkärra, it is not considered to be top priority inserting a walking path for the part of the stream that is missing a walking path today. For the already existing grass walking path it is essential with regular maintenance, especially during the spring and summer periods since the grass needs to be cut so visitors easily can use the path. The alternative is to construct a gravel walking path, but the construction and maintenance costs would then increase and a gravel path would most probably take away the natural feeling that the grass path today provides in a good way.

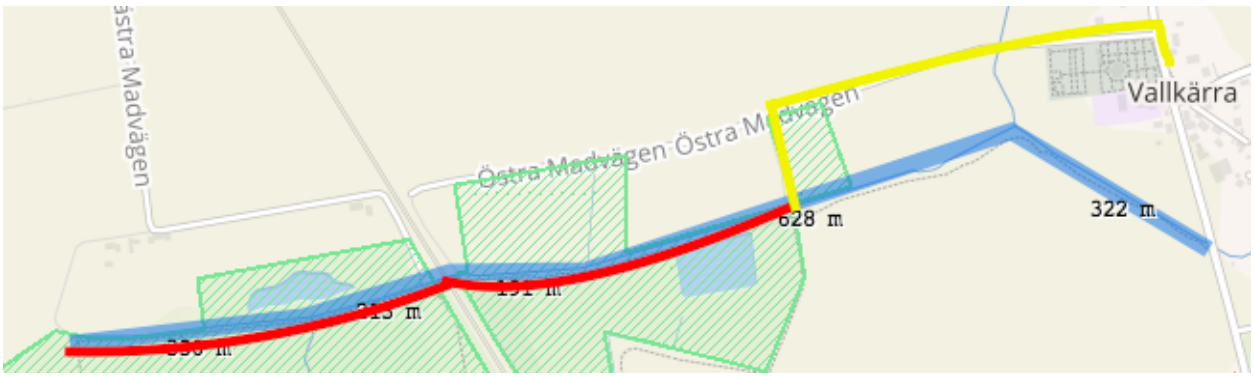

Fig. 4.1. The walking paths along Vallkärrabäcken (blue line). The existing grass walking path (red line) and the existing small road (yellow line). The nature reserve in the area is also marked in the map (green cross hatched area). The map is modified by the authors (VattenAtlas, 2018).

As one is walking along the stream it is difficult to actually see the stream due to the vegetation and the steep slopes, also mentioned in Table 3.2. It is therefore recommended to increase the maintenance in the area and make some more places were it will be possible to see the water. It is believed that such effort will increase the recreational values along the walking path. To be

able to see the water in the stream vegetation needs to be regularly cut of and the erosion problem needs to be handle so it will be safe for visitors to go close to the stream. The restoration work in 2008 reduced sharp edges along some parts of the stream (Naturcentrum AB, 2008). However, this was ten years ago and it is therefore recommended to investigate and evaluate the whole stream to see where restoration needs to be carried out, for example figure 3.4 shows a drainage pipe with a broken barrier at the top right corner which does not fulfil its function. It is also beneficial to check the south basin part in order to avoid lost of agriculture land due to erosion. In the long term perspective is it probably cheaper to restore the whole area at the same time instead of restoring one part now and another part in a few years. However, if one should prioritize some sections it is probably the edges for section R2 and R3. These sections have very sharps edges towards the water and according to one of the respondent during the field study, the walking path along these sections is highly affected by erosion, especially during wet periods. Read more about how to solve the erosion problem in section 4.2 - Erosion.

Additionally, a lack of benches was noted during the field study and also mentioned from one interview, Table 3.2. Therefore, it is suggested to place some more benches in the area, preferable with a nice view of the stream and/or the wetlands. To further improve the area for visitors one should also place at least one toilet along the walking path. The map in Figure 4.2 shows suggested locations for a toilet and for benches. The recommended position for the toilet is a place where it is already today possible to sit close to the water and there is a nice barbecue site with view towards the cow pen. The site is also close to a road which is beneficial from a maintenance perspective. If considered possible to insert toilets in the area, trash baskets should also be placed at the same locations since the maintenance of trash baskets can be made at the same time as for the toilets.

Fig. 4.2. The suggested positions for benches (black dots) and for a toilet (red dot) along Vallkärrabäcken (blue line). The nature reserve in the area is also marked in the map (green cross hatched area). The dots is added to the map by the authors (VattenAtlas, 2018).

The railway

As the walking path reaches the railway it is possible to use an underpass, see Figure 3.3. Since the underpass is placed just above the stream it is a risk that the walkway will be flooded during

wet periods and it is therefore suggested to do some changes at this point. It is important to solve the underpass issue, otherwise there is a risk that visitors will cross the railway trails. The alternatives are to adjust the height of the underpass to avoid flooding (*e.g.* raise the walking platform), make some kind of drainage system to lead away water from the walking path or adjust the depth and/or the width of the stream before the railway.

By reason of the problem of varying flows within the stream due to changes in stormwater runoff during the seasons, the best alternative would probably be to decrease the water flow upstream the railway during wet periods. This can be done by constructing a wetland or most preferably several wetlands which can lead away water from the stream if necessary. Creating wetlands, besides reducing the risk of floods, increase biodiversity, improve recreational values and nutrient retention. If constructed wetlands upstream the railway is not enough in order to avoid floods, combining solutions might be the key. Furthermore, the underpass is gray and dark so it is proposed to add some kind of paintings to the walls such as colorful graffiti to make the underpass nicer to pass. Perhaps this can be achieved by using a local painter or take help from a nearby school.

4.2 Suggestions to improve nutrient retention

This section describes possible actions for improve nutrient retention along the stream.

Constructed wetlands

From a rapport focusing on wetland inventories (VMI) constructed from Naturvårdsverket, the Swedish state administrative authority in the environmental area (Naturvårdsverket, 2009). A wetland is per definition according to VMI, a land type where water is either close, in the ground or just above the ground surface for most part of the year. Also, vegetation-covered water bodies follow under this definition in which at least 50 % of this vegetation needs to be of a hydrofoil sort (Länsstryelsen Jönköping, A). Wetlands can be profitable in mainly three categories which are, reduction of nutrients from agriculture in watercourses and seas, increases the biodiversity and by enhancing the recreational value of the surrounding area. Hence, wetlands can be considered as biological treatment plant and thereby be used as a tool to reach some of the Swedish sixteen environmental quality goals, *e.g.* a rich farming landscape and teeming wetlands.

Many wetlands have been constructed in the vicinity of farming areas where the overload of nitrogen and phosphorous has been a problem. Wetlands reduce the concentration of nutrients by organical binding and sedimentation (Jonasson, 2016). The purifying level of the water depends on the precipitation, the catchment area, the temperature and load of nutrients (Länsstyrelsen Skåne, 2006). Studies in Scania have shown that wetlands optimized for nutrients reduction needs 200 hectare per 1 hectare constructed wetland.

The design of the wetlands is of importance for reducing nutrients and increasing the biodiversity. Important factors for construction are for example the shape, the depth, the vegetation and grazing from cattle that can increase the additional value to the ecosystem. The best way to optimize the biodiversity in a wetland is to construct it with the fundamental conditions and fairly easy measurements (Länsstyrelsen Skåne, 2006). The size of the wetland is not the crucial matter, instead studies have shown that smaller wetlands within a range of 500 meters and at least 200 meters from nearest road is prosperous for amphibians, invertebrates and waders. The conditions to achieve a diverse gene pool and variation of species in the neighboring wetlands are; shallow wetlands with a part that is deeper, a low inclination rate between the ground and water with sharp rounding, a high rate of underwater vegetation and flat surrounding land that will allow flooding along with meandering water, see figure 4.3 (Länsstyrelsen Skåne, 2006). A wetland that is combined with shallow and submerge vegetation and deeper clearer water will result in rich bird fauna. A wetland that is combined with a low water flow and exposed of sunlight, will rise the temperature in the wetland which gives likable habitat for amphibians.

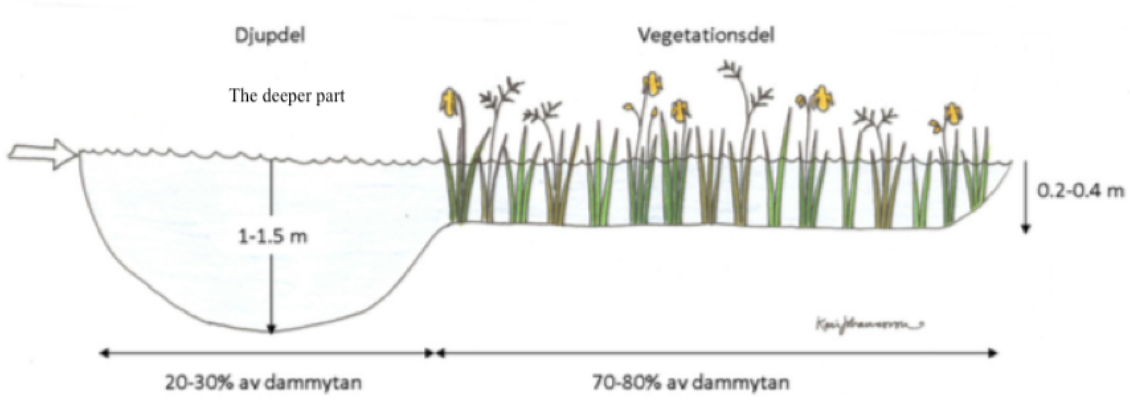

Fig 4.3 Illustration of a wetlands fundamental conditions. of wetland for mainly reduction of phosphorus. But this can also be the habitat favourable for waders. Borrowed from Jordbruksverket, 2015.

The implementation of constructed wetlands has already been performed in this area and one of the wetlands was constructed in 1999 and is parallel to the stream in the downstream part, L2 (Lunds kommun, 2014; Torna Härads Hembygdsförening, 2015). Approximately two-thirds of the project stretch is within the Nöbbelövs Mosse nature reserve where three bigger wetlands have been created as an action plan (see figure 1.2) in order to attempt to restore the landscape to the previous ecosystem. This plan resulted in a successfully achieved transformation from arable landscape to wetlands and very scenic surroundings with open pasture for cattle and meandering water, stretch R1-R4. This transformation is believed to occur from two inlets from Vallkärrabäcken. Theses inlets have their start as drainage pipes and are later creating meandering streams, flooding zones and wetlands within Nöbbelövs Mosse. These inlets are at location R1, figure 3.1, and figure 3.4 shows the appearance and in a corner of the pond at location R4, both in which have an effect on Vallkärrabäcken (Lunds kommun, 2014). There are

some spots along the stretch that are favorable for the project. According to the historical water flow and older property maps, figure 4.5.

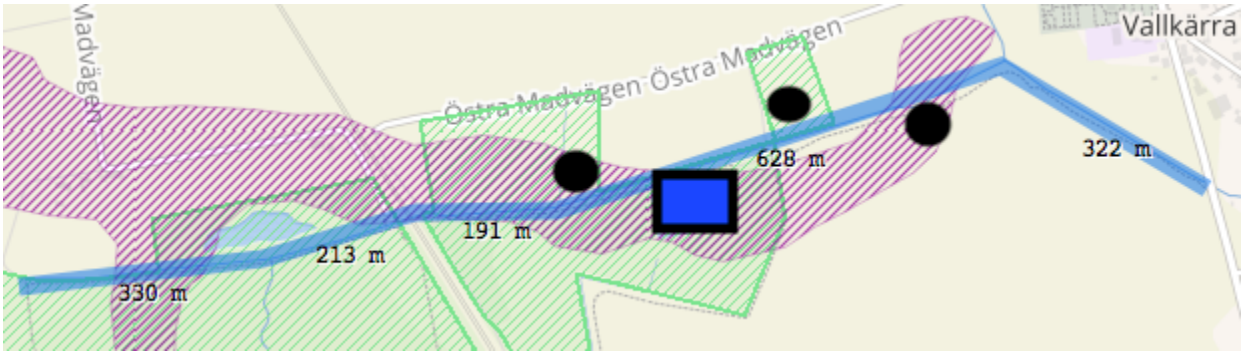

Fig 4.5. The map of the project part of the stream (the blue line) with the nature reserve (green cross hatched area) and the historical water (the purple cross hatched area). The suggested location for new wetlands are the black circles and the range between them will be at the most 130 meters including the pond. The dots and square are added to the map by the authors (VattenAtlas, 2018).

The suggested location for new wetlands would be at two locations in our R4 stretch and in the border of R5/R6 (Figure, 3.1 and 4.5). Even if the two suggesting locations in R4 are in the nature reserve, it may be dismissed due to an attempt to restore Mederna, a culture/ecologic meadow (Lunds kommun, 2014). These suggested sites would be appropriate wetlands emphasizing on biodiversity and recreation purposes rather than focusing on nutrient reduction. As a consequence of the nature reserve, the constructed wetland need to take some other factors into consideration for the design. The vegetation surrounding the pond in R4 and the Oxidation Pond, are decided in the management plan of the nature reserve to consist of low vegetation. This is a preventive action to avoid nesting crow birds and raptors interfering and disturbing the waders, by preying on wader's eggs and chicks. Trees are considered to be favorable for creating shadows, lower the temperature and give habitat variation. The implementation of the nature reserve has resulted to exclude trees for minimizing the risk and today there is a huge variation of nesting waders. This information is also strengthened by the Länsstyrelsen Jönköping (A; B) and Länsstyrelsen Skåne (2006) reports.

Therefore, construction of wetlands in this area would supply additional values to the nature reserve protection- and recreation values. This will increase for example nesting waders and amphibians and common toad (Lunds kommun, 2014, Ekoll, 2018). The methodology for measuring the biodiversity for theses constructed wetlands would be sampling by an educated person in this field to do the inventories of the species (Länsstyrelsen Jönköping, B). This study should be conducted after 3-5 year, due to the time of colonizing, and repeat it after additionally five years. Regardless the pollutions from St Hans Backar, a cleaner water from nutrients will have a positive effect for fishes like trout (brown trout) and loach in Vallkärrabäcken as a whole (Björnström et al, 2008, Bydén, 2008).

The oxidation pond

The Oxidation-pond (oxidationsdammen) in our area is an old treatment pond which closed down in 1977 when the water treatment of Vallkärra was transferred to Källby water cleaning facility. An oxidation pond is one of the biological systems used for the treatment of wastewater in which an interaction between bacteria, algae and other water organism accelerates the water purification by operating in an extended aeration mode. In such a pond biochemical oxygen demand reduction of wastewaters takes place by aiding algal-bacterial growth and efficiently abolishes bacteria, biodegradable organics, as well as the nutrients discussed above before discharging the purified water to the stream. This purification method is cost-effective but very dependent on climatologically parameters such as light, temperature, wind and rain (Tharavath et al, 2013).

Today grazing cattle are surrounding a big part of the pond, but they can not reach the water, due to a small ley of 0,5 meter and fences. The shape of the pond is rectangular with little protection from wind and higher vegetation. According to the Nöbbelövs Mosse management plan it should be floating island but during the field study on the 21th of May, it was only a small log in the water. Therefore, as an expanding wetland area with meandering stream, stretching from Vallkärrabäcken to Nöbbelövs Mosse, this pond could potentially be rebuilt into a wetland. This will allow people to see the water and appreciate the habitat of a wetland consisting of birds, amphibians and fish. The information signs for fish and birds are already put up, due to a Naturcentrum management plan in 2008, financially supported by a LONA-project.

To optimize the oxidation pond would be to take down the ley and allow the water to flow and create a natural shape. The water inlet is already controlled by a drainage pipe from Vallkärrabäcken and therefore periods of higher water level will be under control. Allowing cattle to graze might cause additional nutrients to the watercourse but the grazing will prevent the wetland from overgrowing.

An increase in floating small islands with low vegetation or hydrophilic vegetation will create shadows and resting places for amphibians. And by not implementing fish and crayfish will increase the biodiversity and allow rare species, such as crested newt to thrive (Länsstyrelsen Jönköping, A). Furthermore, to increase the recreation value of the area, a pier in the water with benches, similar to the solution used in Prästmarkens nature reserve in Åstorp, Skaina could be adopted. The suggestions in and around the pond could give the whole area an uplift, both in biodiversity and ecosystem services but also in the recreational value regarding human appreciation.

Estimated costs for creating wetlands

Constructing wetlands during 2018 can be considered a wise investment for a landowner as one may receive fundings from Narutvårdsverket (2018) "wetland investment 2018" as well as fundings from the European Union if requirements are met (European Communities, 2007).

The suggested wetlands will ruffly have a radius of 40 meters, even though a circular form is not the best shape for a wetland, the estimated cost for digging will use the area of a circle. This gives each wetland approximately an area of 5026 m^2. The cost is 40 kr/m^2 and will result in a depth of 1 meter. Which results in a cost of 201 040 kr/wetland with additional expenses.

Erosion

As mentioned before, the risk of erosion due to the sharp edges towards the stream needs to be handled in order to minimize the risk of landslides for visitors using the walking path, avoid land loss and unwanted material in the stream. This can be achieved by implementing bank shaping which stabilize the slope by reducing the sharp edges. One can place some topsoil for sustaining plant growth since vegetation, preferible herbaceous plants, can help binding the soil (SKYE, 2009). An illustration of bank shaping before and after implementation can be seen in Figure 4.6 below.

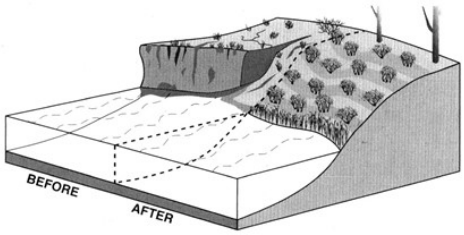

Fig. 4.5. Illustration of bank shaping, before and after implementation (USDA, n.d).

Another solution is to use the method two stage channel that allows the water to flood during high flow events, see Figure 4.7. This kind of system increases the capacity of the channel and reduces the water speed during high water flows. The stream will be able to handle variations in stormwater runoff and the nutrient retention time will be improved (Burchett, 2013). The low flow channel, so called terraces should be 40-60 cm above the stream bottom to avoid erosion (SKYE, 2009). This design will of course need a larger amount of land compared with a traditional channel, however some actions needs to done in order to improve Vallkärrabäcken.

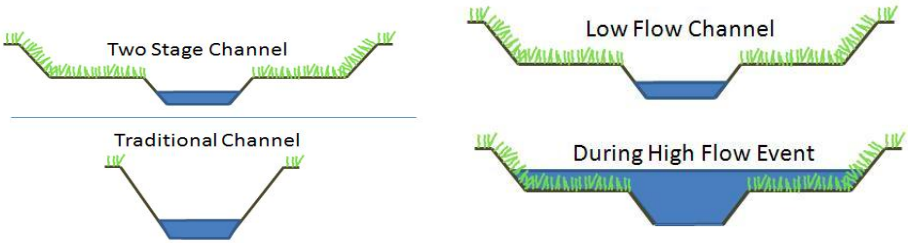

Figure 4.7. Two stage channel and traditional channel (left). Two stage channel during low flow and high flow events (right) (Burchett, 2013).

The erosion problem needs to be handle along the whole stretch, but one has to consider whether the existing trees along the stream can be removed or should remain as they provide shadow which increases biodiversity and reduces the risk of an overgrown stream. On the southern river side it may be an idea to save the trees where it is possible, to optimization shading. The bank shaping method and the two stage channel method can be implement on only one side of the stream if there are places where the value of the trees is estimated high, for example the willow trees along section L6. According to the nature reserve management plan, willow trees are considered to be of culture value and have to take in account when digging in the area is taking place, due to the replacement (Lunds kommun, 2014)

Estimated costs for erosion restoration

Estimation for the digging cost for a slope of 1:2 is shown below where 1 meter of the stretch will result in 1m^3 digging material, the backhoe operator is estimated to be able to dig 500 m^3/ 8 h and cost 850 kr/h.

1684 meter → 1684 m^3 (amount soil needed to be taken away)
1684 m^3 / 500 m^3/8 h ≈ 27 h (working hours)
27 h・850 kr/h = **22 950** kr (costs for one side of the stream)
22950 kr ・2 = **45 900** kr (costs for both sides of the stream)

Important to point out is that these estimations are very rough and that additional costs should be expected. For instance, the soil is recommended to be taken away for combustion and not to be spread on farmland due to the high amount of giant hogweed (*Heracleum mantegazzianum*) in the area (mainly in section R6 and L6).

Buffer zones and Meandering

In order to reduce the high concentrations of nitrogen and phosphorus in Vallkärrabäcken it is recommended to increase the width of the buffer zones, especially in section L5 and L6. These sections consist of agriculture land and by inserting larger buffer zones between the agriculture land and the stream (preferably at least ten meters), the leakage of nutrients into the stream can be reduced. Of course dialog and discussion with the farmers in the area are necessary since their farming land will be reduced if inserting larger buffer zones. The buffer zones can also create different habitats to increase the biodiversity. Vegetation in the buffer zones can increase the uptake of nutrients and contribute shadow to the stream. It is recommended to place more trees in especially the sections L1-L3 due to the lack of shadow in this sections.

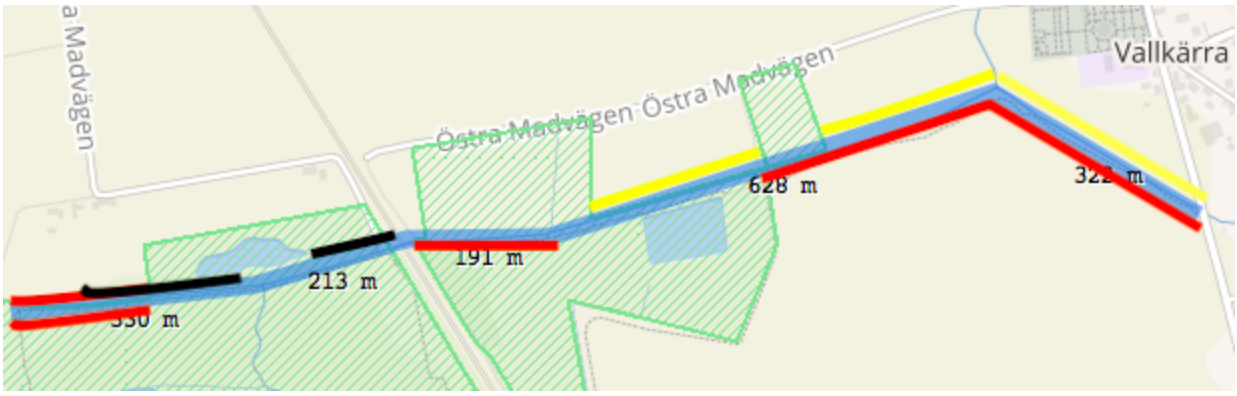

Fig. 4.6. Is an example where actions for reducing erosion, increasing buffer zone and plant trees. The red line indicate where two-stage channel or just trimmering the slopes if most needed. The yellow line is action for buffer zone. The black line is where tree planting is needed. The lines is added to the map by the authors (VattenAtlas, 2018).

Fish Restoration

In the stream, two species of fish are most prominent, stone loach (*Barbatula barbatula*) and the brown trout (*Salmo trutta)*. Restoration measures for these has already been done, mostly along L4 see figure 3.1, but this was in 2008 and have since degraded somewhat (Naturcentrum AB, 2008). Mainly, focus should be given restoring already done measures, such as removing migration obstacles in order to improve migration and also adding new gravel to the bottom as gravel is favorable for fish egg laying. In 2008 at E2, see figure 3.1 a concrete obstacle in the culvert entrance was lowered for easier migration. However, the authors noted that there was no fish further upstream beyond this point. It is unclear whether this depend on the low water level or the barrier itself, further investigation regarding this has to be executed. Restoration measures mentioned before such as re-meandering and adding larger rocks to the stream in order to slow the water also improves living and recruitment conditions for fish. Here a choice must be made whether to meandre the water course or to save the present trees which is shading the water course and therefore cooling it down, to the liking of both fishes.

It should be acknowledged that the authors consider the problem with malformed fish due to toxins from St Hans Backar is beyond the reach of this project since the agenda is to restore a certain stretch of Vallkärra Bäcken. In order to tackle the influx of hazardous substances much larger restoration efforts must be done mainly in the area which this substances are leaking from. Nonetheless, as also mentioned before; a wetland might not be a complete solution for handling toxins but it could help concentrating these and help future clean up processes.

5 Conclusions

Several suggestions have been made regarding the increase of the recreation value and to improve the water quality. For the recreational values valuable suggestions are to install a WC and bins, create visible spots of the stream as well as resting sport such as benches. Make the railway under passage more appealing with colour and prevent flooding, and to improve the maintenance of the walking path especially where it has been affected by erosion.

Improvements regarding the decrease of nutrients in the stream is to construct wetlands, build two stage channel in some parts of the stream, clear away vegetation where the stream is almost overgrown as well as placing rocks at the stream edges to create a meandering feature with time. Further, to prevent erosion of the stream with plantation of trees and creation of larger buffer zones. All these actions for the purpose of decreasing the water flow so that nutrient sedimentation can occur as well as an increase in nutrient plant uptake.

Moreover, the suggestions would also improve the biodiversity and protect the area from floodings.

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Acknowledgements:
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