THE TULLSTORP STREAM PROJECT

THE TULLSTORP STREAM 2.0 – MITIGATION ACTIONS REGARDING ONGOING CLIMATE CHANGE

– Final report of pre study–

Benefits of a combined system of

Multifunctional water reservoirs, Recirculating water with irrigation

&

Customized drainage

This report has been prepared through funding with LOVA grants, thus the report is a public document whose content is allowed to be passed on to other stakeholders. Co-financiers in the project are WWF and Region Skåne.

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Preface

I would like to thank the following organizations and people who have contributed in various ways to the implementation of this pre study:

- The Board of Tullstorp stream economic association that have stood behind the project and gave me the confidence to be the project manager.

- Grants for funding through LOVA and the County Administrative Board of Skåne County, WWF and Region Skåne.

- Peter Malm at HIR Skåne, Christina Huhtasaari consultant in water issues, Ingrid Wesström at SLU, Tuve Lundström at Naturvårdsingenjörerna AB, Olof Persson at SWECO who in various ways contributed with input to the pre study.

Jordberga, spring 2020

Christoffer Bonthron, Project Manager

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Background

The recent extreme weather, with the wet summer and autumn of 2017 and the dry summer of 2018 in fresh memory, presents Swedish agriculture with new challenges. Climate change means that Swedish agriculture must rethink and think in new manners. In order to meet climate change that is rapidly changing the conditions, Swedish agriculture must have access to both productive land and associated water resources and systems to use the water effectively. New forms of support in the form of effect support / result support are also needed, which are based on the effect and result the measures entail and support which means that facilities for storing, recirculating and draining water can be done to a greater extent in a water-holding manner.

Ambition with the project

Historically executed and ongoing water projects (such as the Tullstorp stream project) have been created, designed, operated and followed up from a, largely, strictly ecological perspective with the goal of generating ecological benefits. If the perspective is broadened to include climate change and future water projects, can be driven to achieve both ecological benefits for the environment, but at the same time economic benefits for the landowner as well as social benefits, there is a possibility that water projects will have a larger and broader impact.

Results and continued work

The basic idea of this project is that water should be able to be stored in a multifunctional water reservoir when there is excess of water. When there is a drought the water is "harvested" from the storage and used in a recirculating irrigation system and a system of customized drainage and finally, to a certain extent, returned to the water system. The result of the pre study demonstrates that through a system of the combination of the three components - multifunctional water reservoirs, recirculated irrigation and customized drainage, the opportunity to simultaneously achieve ecological benefit, economic benefit and social benefit is a fact.

During the work with the pre study, it has been noted, in the dialogue with all participating parties, that:

- it requires many and urgent measures to mitigate the effects of climate change
- the type of measures proposed in the pre study is one way forward but more types of measures are needed
- proposed measures are costly and today there are no forms of support to be able to build these types of systems
- there is a need for dissemination of knowledge and experience in planning and implementing proposed measures consisting of a system of different components
- reference systems / pilot projects need to be established where research and evaluation can be linked to verify action effects

The challenge for the future also lies in the fact that there are many different authorities that need to work together to create opportunities for more climate-impact mitigation water projects to be done in the future.

The project's continuation is dependent on support from financiers. The next two phases - phase 1 Pilot project and phase 2 Method development is planned in detail with project plan and budget plan developed. As the project spans several different areas that affect different authorities, it will be necessary to put together a panel of different financiers to be able to continue the project.

1 Introduction

1.1 Background - Problem and the challenges

1.1.1 Wetter and drier

The recent extreme weather, with the wet summer and autumn of 2017 and the dry summer of 2018 in fresh memory, presents Swedish agriculture with new challenges. Climate change means that Swedish agriculture must rethink and think in new manners. Large areas could not be sown in the fall of 2017 as the fields were too wet to run machines. During the dry crisis summer 2018, the possibilities of using water stored in wetlands for irrigation were discussed, but this did not happen as existing wetlands (which are mostly designed with a focus on the ecological perspective) are shallow and dried out in whole or in part parallel to the legality of water withdrawal. was unclear. In addition, some farmers who had water for groundwater outlets realized that their water simply was not enough, either because the groundwater supply was too small or because conditional groundwater outlets were not enough to meet the irrigation needs.

1.1.2 More cultivation in Northern Europe, increased need for irrigation and conflicts around the need for water

The European Environment Agency (EEA) has issued a new report[1] where they assess how food production and agriculture will be affected by climate change. The report reiterates that cultivation in parts of southern Europe can be made more difficult. In some cases, so much that land is abandoned and areas are depopulated. And the slightly warmer climate can instead provide benefits for cultivation in Northern Europe. For Sweden, animal husbandry and agricultural production can benefit from an extended growing season and increased harvests. As a joker in the game for all European countries, there is extreme weather with heat waves, but also floods and hail, which can cause major crop damage. Drought will increase the need for irrigation and it will cause conflicts as a result of the need for water in other areas. The changes in the precipitation pattern will also place new demands on agriculture's soil drainage facilities. It will also lead to the need for water for irrigation will increase.

1.1.3 Overall grip on the water and smarter use

Sydvatten recently issued a report[2] where the state 's that there is a widespread realization that we must bring about changes on many levels, in many areas, and that it must be done urgently.

" It is becoming increasingly clear that there is a lack of a holistic approach to the water issue, while the situation rapidly becoming more acute. Climate change and extreme weather situations with drought and rainfall are becoming increasingly common, making the water resource permanently more vulnerable. Ignorance and conflicts of interest and goals can create irrational solutions. "

“Through changing, to more efficient and smarter use of water, the freshwater resource can last longer. Many measures within the municipality, agriculture and industry are relatively easy to implement, but are hindered by low awareness, the issue is undeveloped and the lack of insight into the value of water. Other measures require new forms of financing, a clearer priority in water use and a modernization of the water legislation. Ecosystems must be a part of the whole and the risks of pollution are taken into account. Collaboration partly over the value chain, partly in a catchment area, and partly around issues such as irrigation, drainage and municipal water and gas activities need to grow and develop."

1.1.4 Current support system

In the current support system, it is possible to receive support for the construction of wetlands. Irrigation dams can get some support depending on the form of wetlands because they can provide large environmental benefits in the landscape. Installation of irrigation systems and drainage systems are

[1] Climate change adaptation in the agriculture sector in Europe, EEA report (European Environment Agency), No 04/2019

[2] Klimatsäkert vatten, Sydvatten juni 2019

excluded from the support system except for controllable drainage, where it is possible to obtain support for the regulation well but not for the drainage system.

1.1.5 In summary

In order to meet climate change that is rapidly changing the conditions, Swedish agriculture must have access to both productive land and associated water resources and systems to use the water effectively. New forms of support systems are also needed in the form of effect support / result support based on the effect and result the measures entail and support which means that facilities for storing, recirculating and draining water can be installed to a greater extent in a water-holding manner.

1.2 About the initiative / project

Using the above problem picture as background, the Tullstorp stream Project Board in spring 2019 decided to give the Project Manager the task of starting up, financing and running the overall project Tullstorp stream 2.0, and initially Tullstorp stream 2.0 - pre study Multifunctional water reservoirs, Recirculating irrigation and customized drainage. Financing was secured with WWF, LOVA and finally Region Skåne. In order to create a greater weight behind the project Högestad and Christinehof was connected which has a long history and knowledge on environmental and water conservation projects and Naturvårdsingenjörerna AB participated in the project with technical documentation.

1.2.1 The Tullstorp stream project

The Tullstorp stream project has become an extensive and well-known water conservation project of national and international interest. The overall goal of the project is to reduce eutrophication to the Baltic Sea and contribute to a good marine environment. It is especially noted that it is the landowners themselves who run the Project. Likewise, the overall approach to the 6 300 ha river basin is a crucial prerequisite for the implementation of the project plan. The Tullstorp stream project started in 2009 and until today some 40 wetlands has been constructed on approximately 150 hectares and 11 km of the stream is restored. These measures have reduced the nitrogen content of the river by 30% and the phosphorus content by 50%.

1.3 Overall project objectives

Historically executed and ongoing water projects (such as the Tullstorp stream project) have been created, designed, operated and followed up from a, largely, strictly ecological perspective with the goal of generating ecological benefits. The pre study is the first step in a larger, climate focused, projects around multifunctional water reservoirs, recirculating irrigation and customized drainage. The overall aim of the entire project is climate-related by creating the conditions for future water projects to be run to achieve both ecological benefit for the environment and economic benefit for the landowner as well as community benefit. This is to be done by exploring, investigating and strengthening the possibilities of installing multifunctional water reservoirs, recirculating irrigation and customized drainage. This will increase the motivation of landowners to create wetlands with multiple functions as well as systems for recirculating irrigation and customized drainage.

1.4 Overall project plan

The project is based on a holistic view of a water body / watercourse - by studying the entire river basin around a river, a stream, or a ditch body - in this case the Tullstorp stream. The project consists of 4 phases in addition to the pre study (see figure below) and will be run by Tullstorp stream's economic association, together with a number of partners, as a further development of the successful Tullstorp stream project and the Tullstorp stream method. Most of the project will concentrate on Tullstorp stream and its river basin, while some parts are made at Högestad & Christinehof.

Pre study
Make it possible for the project idea to go from idea to reality.

Phase 1 - Pilot project
Construction of reference systems for multifunctional wetlands and recirculating irrigation in the catchment area of Tullstorp stream and at Högestad & Christinehof. The pilot project includes both newly constructed wetlands but also the development of existing wetlands as well as the construction of systems for recirculating irrigation.

Phase 2 - Method development
Development of a working method / process for creating a holistic view and enabling a holistic approach to a body of water / watercourses can be made. A guide / description for the design and construction of systems for multifunctional wetlands and recirculating irrigation is developed. The final result is compiled in a manual.

Phase 3 - Full scale test
The entire watercourse of the Tullstorp stream and its catchment areas are analyzed from a holistic perspective on water management. Existing measures (such as wetlands, two-stage ditches, overflow beds, etc.) are supplemented by the construction of multifunctional water reservoirs, recirculating irrigation and customized drainage.

Phase 4 - Evaluation
Overall analysis of how the measures implemented within the project have resulted in both ecological benefit for the environment and economic benefit for the landowner as well as social benefit. What trends and opportunities can be demonstrated? What conclusions can be drawn? The analysis should also point out if there are areas where continued need for in-depth analyzes and any research is needed.

1.5 The ambition of the entire project - Expected result

The impact of the project is estimated to be:

- Reduced nutrient supply to the Baltic Sea.
- Flooding, erosion, cleaning needs to a lesser extent.
- Increased biodiversity in and around the waterways and wetlands.
- Improved cultivation and higher yield on the land.
- Good ecological status in watercourses and coastal waters.

We also believe that this project will lead to more wetland projects being implemented as there is also a financial benefit to the projects and this in turn will lead to:

- Swedish agriculture gains better resistance to extreme periods of drought and drought.
- The water-holding, water-regulating and groundwater-forming opportunities in the landscape are being strengthened.
- More surface water is used for irrigation and the plant nutrients that are in circulation are reused by recycling nutrients and returning them to growing crops to reduce emissions to the Baltic Sea.
- The social benefits of wetland projects are strengthened by linking wetlands projects (which form a puzzle piece) with the County Administrative Board's action plan for regional green infrastructure (large puzzle).
- The regional environmental objectives, national environmental quality objectives and the EU Water Directive are achieved on a broader front.
- Swedish agriculture produces more food and also in an environmental way.
- A basis is created for discussion about new design of support for farmers linked to multifunctional wetlands and recirculating irrigation as a supplement to existing support for the planting and management of wetlands.

1.6 Purpose (pre study)

The purpose of the pre study is to take the project idea from idea to reality. This is done through that the project plan, the pre study and the continued project is anchored with multiple co-financiers and land owners who are interested in constructing multifunctional water reservoirs, recirculating irrigation and customized drainage.

1.7 Objectives (pre study)

- At the final report presenting a Project plan and Budget plan for future work (next phases), see reference in Appendix 1.
- Develop proposals in areas within the catchment area of the Tullstorp stream and within Högestad & Christinehof's fields with the right conditions for entering Phase 1 - Pilot project.
- Compile a report containing discussion and, if possible, definition of multifunctional water reservoir, recirculating irrigation, customized drainage, irrigation technology (linked to the best available technology). The report will also highlight nature conservation and social benefits.
- Work on a plan to create a water budget/balance for the Tullstorp stream.

1.8 Methodology (pre study)

The pre study has been carried out by workshops to establish the Project plan and Budget plan. Literature studies with a review of current reports for the subject and compilation of problem picture, current situation and discussion about possible definitions and need for continued work in the project.

Subscriptions and investigations from sub-consultants:

- Tuve Lundström, Naturvårdsingenjörerna - technical basis for suitable systems to be included in phase 1 - Pilot project
- Olof Persson, SWECO - description of methodology for developing a water budget

Interviews - during the project, the following people were interviewed and contributed with supporting material:

- Peter Malm, Water Advisor and Agronomist, HIR Skåne - basis and cost picture for drainage, adjustable drainage and irrigation
- Christina Huhtasaari, consultant in water issues - experiences and data from Gotland regarding storage and use of surface water for irrigation
- Ingrid Wesström, SLU - experiences and documentation regarding adjustable drainage and underwatering

All interviewed persons have responded with great enthusiasm and great commitment to the issues we have brought with us. All in all, we can conclude that there is a very widespread understanding that we need to achieve change on several levels, in many areas and that this must be done urgently. Big and warm thanks for your generosity and your wise and insightful contribution to this work. It is our hope that our work will inspire increased interest in water issues and stimulate broad discussions that lead to concrete and necessary changes.

1.9 Delimitation (pre study)

This pre study addresses the agricultural landscape perspectives and challenges as well as opportunities to make changes. The pre study leads not in any comprehensive solution to the water situation linked to the climate changes taking place and nor any comprehensive solution for agricultural water management and water management, but however, an analysis of how multifunctional water reservoirs, recirculating irrigation and customized drainage can be part of the solution to the problem picture. The focus will be on mapping and investigating which benefits are reinforced by a system with multifunctional water reservoirs, recirculating irrigation and customized drainage.

2 Multifunctional water reservoirs, Recirculating water with irrigation & Customized drainage

2.1 Discussion

Historically executed and ongoing water projects (such as the Tullstorp stream project) have been created, designed, operated and followed up from a, largely, strictly ecological perspective with the goal of generating ecological benefits. If the perspective is broadened so that future water projects can be driven to achieve both ecological benefits for the environment, but at the same time economic benefits for the landowner as well as social benefits, there is an opportunity for water projects to have a larger and broader impact.

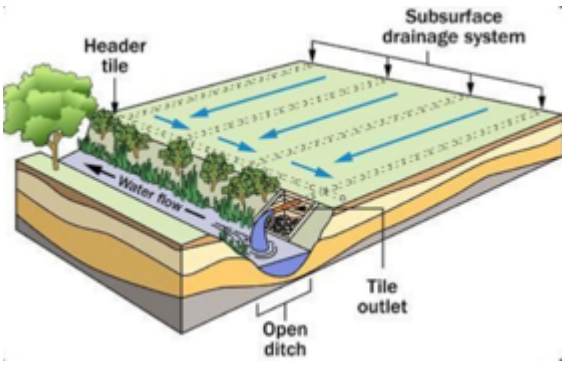
Wetlands are a concept that has existed for a long time and has, by many people, a bearing on ecology and the environment. Irrigation ponds are a concept that occurs and is often associated most with the possibility of irrigation outlets being created and not whether or how much environmental benefit is created. In order not to get caught up in historical and habitual thought patterns, it is proposed that the concept of multifunctional water reservoirs to be introduced and used as a description of the system of water surfaces created within the framework of this project and similar projects in the future.

2.2 Multifunctional water reservoirs, Recirculating water with irrigation & Customized drainage

The basic idea of this project is water to be stored in multifunctional water reservoirs when there is excess of water. During drought water is "harvested" from the water storage and use in a recirculating irrigation systems and systems with appropriate drainage and finally, to a certain extent, returned to the water system.

Multifunctional water reservoirs

Recirculating irrigation



Customized drainage

(Pictures – Energiforsk, MAHER SH och SlideShare)

3 Multifunctional water reservoirs

3.1 Discussion

Wetlands are often multifunctional and provide a variety of ecosystem services that we depend on for sustainable community development. The Swedish Environmental Protection Agency has in its series of fact sheets[3] identified the following 6 features / benefits of wetlands:

1. **PROMOTES GROUNDWATER FORMATION**

Wetlands can store water during periods of the year with a surplus of water, which can strengthen the groundwater levels during periods of low recharge.

Focus areas for strengthening groundwater formation should be infiltration-prone soils high up in the catchment area. In such areas there are good opportunities to identify so-called inflow areas where there is a replenishment of groundwater. Farther down in the discharge areas located near water bodies are often already saturated with water and it can be difficult to amplify the groundwater.

2. **PROTECT FROM DROUGHT (water-holding ability / water storage)**

Wetlands can mitigate the effects of drought by storing water longer than the surrounding landscape. River basins with high water-holding capacity (many reservoirs, such as wetlands and lakes) react more slowly during droughts, as the residence time of the water in the landscape increases.

Wetlands can increase the province's water-conserving capability. During periods of drought, a wetland can allow a certain water withdrawal, which can relieve the groundwater reservoir. If it is possible to combine large regulatory volume with flat and lush beaches, as well as shallow aquatic environments in parts of the wetland, conditions are also created for rich animal and plant life.

3. **REDUCES FLOOD RISK (flow smoothing)**

Wetlands can hold and balance the water flow, creating a flow equalization that can reduce the effects of a flood.

Restoration and planting of wetlands high up in river basins can have a smoothing effect and reduce the flood risk in the lower-lying areas. It is usually most cost-effective to restore former wetlands, where there are already natural flows on site. Restoration measures can advantageously be focused on wetlands that already serve as natural leveling reservoirs. The location of wetlands in the catchment area is crucial for the flow equalization. A water-saturated wetland can amplify the effect of high flows because the control volume is small.

4. **MAINTAINS BIOLOGICAL DIVERSITY**

Wetlands are one of the richest biotopes in the country. Loss of suitable wetland habitat is one of the biggest threats to approximately 800 red-listed species.

In parts of the agricultural landscape where there are no natural wetlands, landscaped wetlands can increase biodiversity. Landscaped wetlands are often used as nutritional traps and favor only a few highly competitive tall species that can push away other vegetation and accelerate overgrowth. Therefore, in order to promote biodiversity, the water level should be allowed to vary, the nutrient supply be limited and the beaches be flat. Without care, many wetlands grow full. Therefore, it may be a good idea to allow the wetlands to dry out, or to be emptied of irrigation, from time to time to allow for maintenance (for example, grazing, mowing or clearing). Draining the wetland can also help keep the wetland fish-free, which benefits many amphibians who find it difficult to establish themselves in fish-fed water. Fish also compete with many wetland birds for the insects and other small animals that thrive in the wetland. Many fish species also cloud up the water, which undermines underwater plants and increases the risk of algal blooms.

[3] Våtmarker bidrar till ett hållbart samhälle, Naturvårdsverket

5. REDUCE EUTROPHICATION

Wetlands purify the water from, among other things, nutrients (nitrogen and phosphorus) and environmental toxins and therefore act as nature's own wastewater treatment plant. Wetlands are therefore important for reducing nutrient leakage from soils to rivers, lakes and seas that are sensitive to eutrophication.

The wetland should be located near the recipient to be protected from nutrients. In coastal areas, wetlands can also function as a reproduction room for fish or as a resting place for birds. It is important that the wetland receive efficient water conversion (hydraulic efficiency) so that the entire wetland surface is used for water purification. In order for a wetland to achieve the best nutrient reduction, the residence time of the water in the wetland should be long enough to allow the nutrients to settle.

6. REDUCE CLIMATE IMPACT

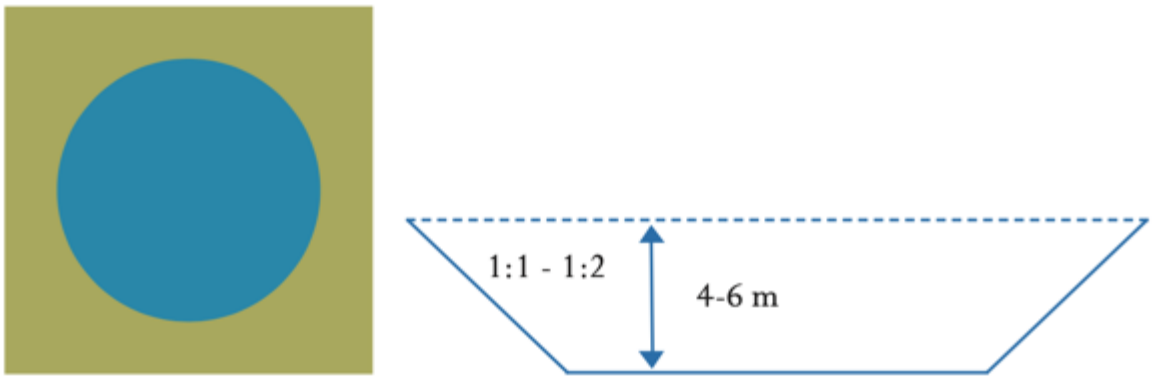
Peat is a soil that contains large amounts of carbon and is formed in the oxygen-poor and wet conditions in wetlands. Upon extraction, the peat layers are oxygenated so that the stored carbon oxidizes and exits to the atmosphere in the form of carbon dioxide. The total greenhouse gas emissions from depleted peatland make up about 20 percent of Sweden's total annual climate-impacting emissions. By moisturizing the peat soil, the rate of oxidation decreases and the storage of carbon increases, which is positive for the climate.

Dedicated agricultural land located on soils with deep peat layers should be prioritized in restoration work as these lands are a major source of greenhouse gases. Ditched arable land should be prioritized over diked pasture, since the emission of greenhouse gases is likely to be higher on arable land. Priority is given to agricultural land that is on peat land and which has been taken out of production as it is unused land that does not contribute to any social benefit. Nutrient-rich soils are preferable to nutrient-poor ones because they can withstand large emissions of nitrous oxide. It should be noted that nutrient-rich soils can be rehydrated during nutrient-rich soils, which can cause eutrophication downstream. For forest land, nutritious and drier land should be prioritized for the best effect. Peatland has usually been ditched to increase productivity in agriculture and forestry. For this reason, it may be good to prioritize land that is no longer used.

The above summary does not intend to describe in detail or technically how a wetland is designed to achieve various functions/benefits. The intention is instead to point out that there are several different purposes to reflect on when you start to think about building a wetland.

3.2 Experience from similar projects - combined wetlands and irrigation ponds

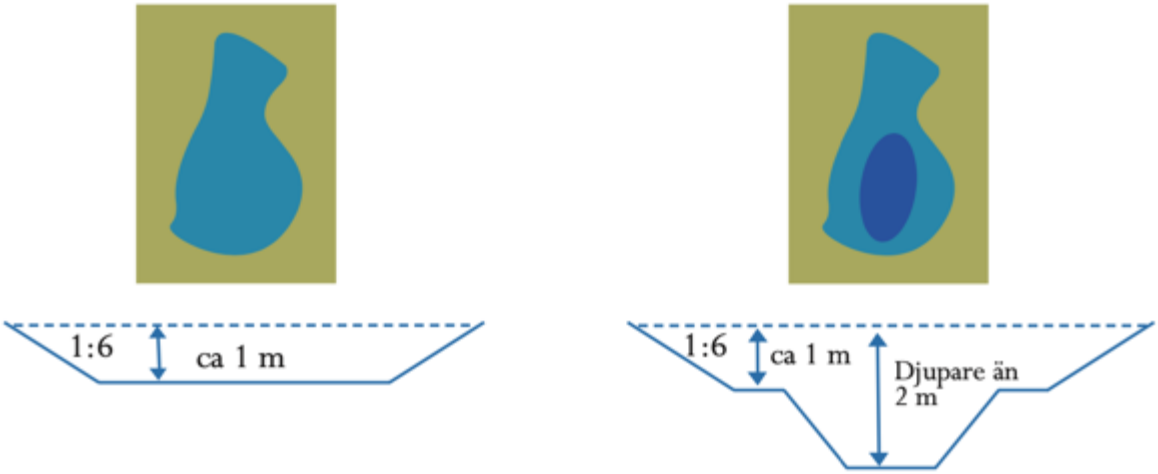
An irrigation pond (sometimes called irrigation magazine) is deep, has steep slopes and is usually designed as a square or circle, possibly covered with a cloth at the bottom. An irrigation pond is a good way to utilize excess water in nature if it is replenished with drainage water from ditches or pipelines, and when there are high flows, from watercourses.



Principle sketch of irrigation pond[4]

[4] Våtmarker och bevattning, Länsstyrelsen i Skåne

A wetland is normally shallow with flat slopes and irregular shape, and is never covered with cloth. A wetland used for irrigation needs to be large enough to hold enough water, and yet be shallow. An alternative is to provide the wetland with a deep hole that stores more water.



Principle sketch of wetland and wetland equipped with deep hole[4]

Experience:
In Gotland, groundwater withdrawals are not an option for agricultural irrigation, but agriculture is referred to extract surface water during high-flow periods (October-March). Since there is an excess of precipitation a number of combined irrigation ponds and wetlands are made[5].

- When large amounts of water are stored in ponds, there is a risk of waves that may in turn cause erosion of the dam edges. To reduce the erosion risk, some wetlands have been designed with peninsulas / headlands with good success. Another alternative that has been tested and works well is to mix depths and bases.
- In some projects, a defining "embankment" has been made that divides the wetland into a shallower and deeper part. In this way, the deep part can be emptied if necessary, but the "embankment" will help the shallow vegetation-rich part remaining water-filled and performing its function throughout the year.
- Mixing depths and bases is also positive as it strengthens several different functions / benefits of the wetland - the bases are positive for biodiversity and the depths serve as sediment traps, reservoirs and facilitate irrigation. The combination of depths and bases also increases biological diversity as the needs of more diverse animals and plants are met.
- Within Segeåprojektet[6] it is planned a pair of combi wetlands (irrigation pond and wetland) which has a shallower and deeper part for as effective nutrient retention as possible in combination with water withdrawal. In these projects, the landowner himself will be responsible for the additional costs of constructing the deep parts.
- SLU has conducted an experiment on Listerlandet[7] where 27 smaller ponds / wetlands (total 355,000 m^3 storage capacity) were constructed and provided with drainage water from surrounding agricultural landscapes (163 km^2) and where the water is used for irrigation of crops. The dam/wetland design consists of both "natural" (natural material at the bottom of the pond) and "artificial" (plastic / rubber cloth at the bottom of the pond) techniques. The result shows that the small ponds / wetlands function as good traps for N and P at the same time as they constitute a water source for irrigation during the growing season and thereby contribute to good water management. The concentration of N decreased by 2 to 16 times in the different ponds / wetlands and the concentration of P was halved. The water requirement for irrigation in the area could be met to 20% with recycled drainage water.

[5] Christina Huhtasaari konsult inom vattenfrågor, telefonsamtal 2020-01-10

[6] Filip Hvitlock, Ekologigruppen, telefonsamtal 2020-01-15

[7] Storage and reuse of drainage water, Wesström I and Joel, A – summary from XVIIth world congress of the international comission of agriculture and biosystem engineering, June 2010

3.3 Proposed definition - Multifunctional water reservoirs

Based on the review above, a wetland often has several different benefits, or multifunctional benefits. However, the purpose of why the wetland was constructed could be ONE specifically based on what is to be achieved or based on the support used at the construction. The proposal on the definition of the concept of multifunctional water reservoirs will therefore be based on both the purpose behind the construction of the wetland and the outcome of the design:

*"A multifunctional water reservoir is a wetland system that have been constructed in order to achieve more than one advantage / feature and designed so that more than one advantage / feature is achieved. The main purpose / function is to **store** surface water and nutrients to constitute a water source for irrigation outlets."*

3.4 Identified questions for continued work

The following questions have been identified and will try to be answered in the next part of the project - phase 2 Method development.

- ⇨ How to store as much water as possible so that the buffering capacity increases, groundwater formation increases and there is water left during dry periods that can be used for irrigation?
- ⇨ Design of multifunctional water reservoirs?
- ⇨ The benefit of multifunctional water reservoirs (which benefits are enhanced and added in addition to the benefits of "traditional" wetlands)?
- ⇨ What ecological benefits, economic benefits and social benefits can be achieved through a system of multifunctional water reservoirs?
- ⇨ Surface water from lake, pond, river or stream and trenching / drainage water - what can be used?
- ⇨ Can stormwater from urban areas be used?
- ⇨ Can stormwater from the Swedish Transport Administration's roads be used?
- ⇨ Combining surface water and groundwater for irrigation - opportunities and advantages and disadvantages?
- ⇨ How is the streams top / low flows, temperature etc. are affected. if more wetlands with larger water bodies are built?
- ⇨ When is there a lot of nitrogen / phosphorus in the water? (according to Synlab's reports, it is most nitrogen and phosphorus transport during the months of December - March) How long does it take to settle? When is the best time to take water into the pond from an environmental perspective (most nutrients in the water in the drainage pipes / river) vs. irrigation perspective (most nutrition remains in the water when watering)?

4 Recirculating irrigation

4.1 Discussion - Irrigation

Swedish irrigation has a history of good access to water, which means that most of all irrigation consists of groundwater drilling as a water source. In this project we want (in the preliminary study to lift and in the future project to investigate) the possibilities and effects of recirculating irrigation with surface water stored in multifunctional water reservoirs.

4.1.1 Irrigation technology in Sweden today[8]

In Sweden, today, exclusively irrigation machines/technology is used in the form of large-scale spreader (also referred to as irrigation cannon or cascade spreaders) that consume large amounts of water and electricity. This technique is also sensitive for wind even at moderate wind. The wind affects the application so that more water ends up in the tailwind and less in the headwind which in turn can increase the plant nutrient leakage from the soil by transporting nutrients with the water into ditches and drainage systems. The uneven spread also results in uneven quality and thus poorer yield. The development has therefore gone from large spreaders to ramp spreaders that have many small spreaders or nozzles, which means that the distribution of water becomes more even also in relatively strong winds. The ramp riders also have lower working pressures, which means a lower energy demand. The disadvantage of ramps is that the work requirement for moving increases. These conventional irrigation systems need for major work in combination with the climate change that drives us to be more economical with water in Sweden have initiated a startup of system with precision irrigation - pivot - and linear systems.

Large scale spreader[9]

Ramp spreader[9]

[8] Bevattning och växtnäringsutnyttjande, Greppa näringen 2006

[9] www.bauer-at.com

Linear system[9]

	Large scale spreader	Ramp spreader	Pivot and linear systems
Advantages	Cheapest Good for irregular fields Good when there are field obstacles Low maintenance cost	Less wind sensitive Gentle water application Low electricity and water consumption	Not wind sensitive Gentle water application Very low electricity and water consumption Minimal work effort Best irrigation efficiency
Disadvantages	Wind sensitive Labour intensive - requires many transfers May increase surface water runoff from field	Very labour-intensive when moving Sensitive to field obstacles	Requires fields free of obstacles and larger fields

Matrix with advantages and disadvantages of various irrigation techniques

4.1.2 Best Available Technique (BAT) for irrigation

Based on the above review of the various irrigation techniques, it is found that the different methods have their advantages and disadvantages mostly linked to the physical conditions that exist in place. From this, it is not possible once and for all to determine what is the best available technique for irrigation in general, but this must be determined for each individual project. However, where it is possible and possible to choose between the techniques, pivot and linear systems should be chosen in view of their low electricity and water consumption and gentle water application which favors water and nutrient absorption in crops.

4.2 Experience from similar projects

Recently, a few major pivot and linear systems have been established in Sweden. Installation manager [10] for projects in Ystad, Kristianstad and Gotland mean that the owners of the systems are very satisfied with their installations and confirm that the technology has the advantages listed in the matrix above. The economic benefit to the landowner is that they are having significantly higher harvests and the introduction of, for the farms, new crops. The social benefits can thus also be demonstrated by the fact that more food can be produced and new crops to be introduced. The systems in Ystad and Kristianstad were commissioned during the dry summer 2018 and, despite the extreme drought, resulted in harvests well above normal harvests, which demonstrates the social benefits - that agriculture gains better resistance to extreme periods of drought. The ecological benefits of nutrient purification through uptake in crops is nothing the landowners have been able to judge.

The ecological benefit, the economic benefit to the landowner and the social benefit are not scientifically proven, which indicates the need for more projects like this and that this project may continue into the next phases where these issues / theses will be further addressed.

4.3 Proposed definition – Recirculating irrigation

Based on the reviews above, there are several different techniques for returning the water to growing crops. The different technologies have their advantages and disadvantages and also have limitations based on the physical conditions in place. The proposal on the definition of a recirculating irrigation therefore takes base in the ambition to bring as much as possible of the surface water and the nutrients stored in a multifunction reservoir using the best available technology (electricity- and water consumption):

*" Recirculating irrigation is a system consisting of one or more techniques in combination, based on the physical conditions in place that **returns** the most possible volume of surface water and nutrients stored in a multifunctional reservoir to growing crops in the field designed with the best available technology (electricity and water consumption)."*

4.4 Identified questions for continued work

The following questions have been identified and will try to be answered in the next part of the project - phase 2 Method development.

- ⇨ What components and functions can be included in a system for recirculating irrigation?
- ⇨ What ecological benefits, economic benefits and social benefits can be achieved through a system of recirculating irrigation?
- ⇨ How to use the stored surface water in the best possible way and hoe to irrigate as much area as possible?
- ⇨ How is as much plant nutrition as possible returned to growing crops?
- ⇨ Designing of resource-efficient Best Available Technique (BAT) for irrigation?
- ⇨ The benefits of irrigation?
- ⇨ How is the water content of the arable land controlled in the best way so that as much water and plant nutrition as possible can be recycled?

[10] Östorps bevattning, telefonintervju med Michael Hjortenholt, 2020-01-20

5 Customized drainage

5.1 Discussion - Drainage

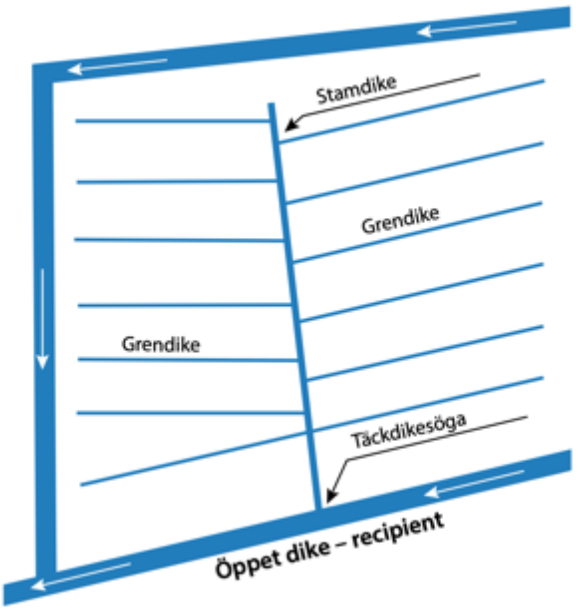
Well-functioning drainage is a basic prerequisite for agriculture. Drainage of arable land contributes to faster drying in the spring, better soil bearing capacity for machines and reduced risk of soil compaction. This leads to better soil structure and thus better aeration and penetration of the soil profile. The drainage usually results in a larger proportion of the drainage passing through the soil profile and the surface drainage decreasing while increasing the outflow of nutrients. In Sweden, the nutrient leakage from arable land is usually greatest during the winter and early spring due to an excess of rainfall and a limited need for plant nutrition in the crop during this period.

A well- functioning drainage increases production in the field and is a good measure for the environment. The crops can absorb more plant nutrients and the risk of nitrogen and phosphorus losses decreases. A better infiltration and soil structure help to reduce the climate impact of cultivation per kilo of product. At the same time, the possibilities of coping with a dry period are improved.

Periods of more intense rainfall create a need to be able to control the water content of the arable land. Some periods require draining as much water as possible and some periods there is a need to retain water. The fact that drainage needs vary during the year is not something that traditional drainage systems are designed for. Regulated drainage, on the other hand, makes it possible to vary the drainage intensity according to the drainage requirement.

5.1.1 Cover drainage

Most arable land that has had a need for drainage already has some form of origin system from the late 1800s or early 1900s when the large ditching measures were implemented to ensure food supply. These ditching measures were carried out on a large scale and ditching companies and soil drainage companies were formed. The condition of the drainage systems is in varying form depending on how they have been maintained over the years. Many drainage companies also have an unclear ownership and responsibility structure since the area when they were built consisted of many smaller farms, while today it consists of few but larger units.



Cover drainage[11]

[11] Täckdikning – för bättre skörd och miljö, Jordbruksverket 2018-2

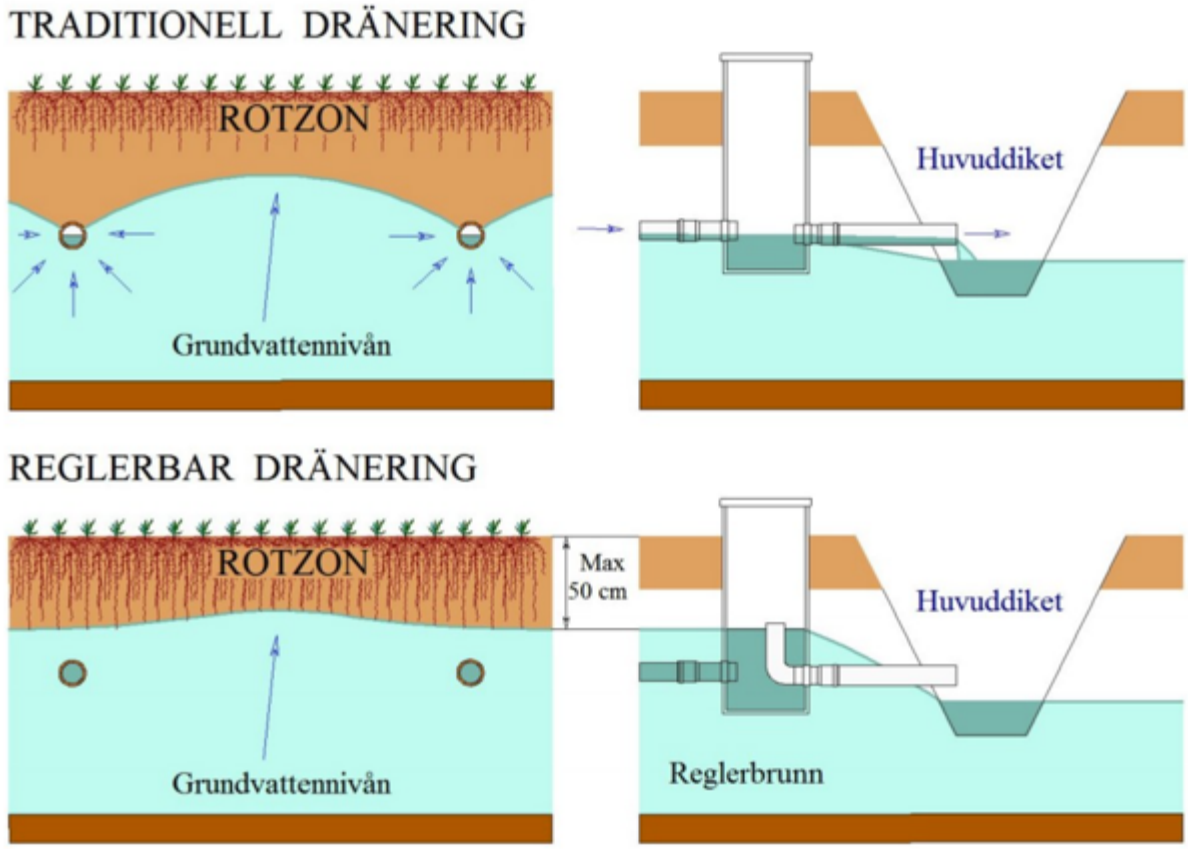
In a report from the Swedish Board of Agriculture[12] it is noted that the drainage of the Swedish agricultural land has been neglected. Climate change will place additional demands on the drainage systems. Changes in the climate affect the drainage need through increased rainfall, less shingle, longer growing season and longer dry periods. Therefore, taking into account modern cultivation systems, more irrigated area and environmental aspects, the need for dewatering will increase.

5.1.2 Traditional drainage

With a traditional drainage system, the soil is drained according to projected drainage intensity. This means in some situations that excessive water is drained away from the root zone.

5.1.3 Controlled drainage

Controlled (adjustable) drainage makes it possible to vary the drainage intensity according to the drainage requirement. By placing standpipes in the wells on the trunk line, the groundwater level in the soil can be regulated. The water level can be lowered at times for seedbed preparation, harvesting and during periods of high rainfall. The drainage system then works as usual. During periods when the drainage requirement is small, the water level can be raised. As a result, water can be retained in the soil and utilized by the plants while reducing the nitrogen leakage at the source.



Traditional and controlled drainage[13]

[12] Avvattning av jordbruksmark i ett förändrat klimat, Jordbruksverket 2018:19

[13] Rasic Zivko, Segeåns Vattendragsförbund och Vattenråd

	Controlled drainage
Advantages	Better nitrogen uptake and less fertilizer requirements Reduces water runoff and nutrient leakage Improves the field's water management Increases harvest Smoother growth Minimizes rust precipitation Reverses nitrification
Disadvantages	Regulatory wells can become barriers to cultivation Higher construction costs compared to conventional drainage Setting the appropriate groundwater level is labour-intensive May increase denitrification

Advantages and disadvantages of controlled drainage**Fel! Bokmärket är inte definierat.**

Ideal conditions for controlled drainage are soils with relatively high hydraulic conductivity and with a naturally high standing groundwater surface or a dense soil layer at a depth of 1-3 meters. This is necessary to get a quick reaction in the system and to keep the water within the field. With a slope greater than 2% in the field, it is considered not suitable for controlled drainage. This is because increasing level differences in fields require more control wells, which results in increased costs.

SLU has carried out a comprehensive mapping[14] of the potential agricultural land where controlled drainage can be applied in the most nitrogen leak-prone areas in southern Sweden. The report presents a matrix for suitability classification in different classes based on the properties of slope, land use and permeability. The study shows that in southern Sweden's coastal areas there is great potential in terms of soil type and slope to apply controlled drainage. The study also finds that others are important factors such as drainage requirements, normal groundwater levels and the presence of a dense layer at depth also need to be considered in order to finally determine if an area is suitable for controlled drainage. A continuation study[15] was also carried out to take these factors into account where information on existing drainage systems, local knowledge of the drainage systems' status from landowners and physical examination of soil properties in fields were investigated. The result shows that there is a large amount of information about existing drainage systems in the archives but of varying quality. Landowners' local knowledge is valuable and useful, but it was found that more information is needed for landowners about how they can improve their drainage in the future - designing systems, expected positive effects on water quality and nutrient leakage, maintenance, financing, etc. Regarding current groundwater levels and dense layers at depth are found that where there are existing drainage systems, these have been constructed based on either the groundwater level being high or that there was a dense layer at depth or both. Finally, it is summarized that there is great potential for controlled drainage in southern Sweden, but that there are many parameters that need to be met. Furthermore, information on existing drainage systems, both scope and status, is required and this needs to be digitized in database form.

Ekologgruppen[16] has, on behalf of the Segeån Water Council, examined the conditions to establish controlled drainage on arable land within the Segeån river basin. The approach largely follows the suitability rating that SLU has developed (described in the section above), but a link to a map layer for agricultural blocks has also been made to create a priority and thus facilitate an initial assessment of where the conditions can be good. The result shows that there are many areas suitable for controlled drainage.

[14] Reglerad dränering, topografiska och hydrologiska förutsättningar i södra Sveriges kustnära jordbruksområden, SLU 2003

[15] Mapping suitability of controlled drainage using spatial information on topography, land use and soil type, and validation using detailed mapping, questionnaire and field survey. SLU 2009

[16] Reglerbar dränering inom Sege å – GIS-verktyg för identifiering av lämplig åkermark, Ekologgruppen 2018-01-22

5.1.4 Underwatering

In fields with suitable topographic and hydrological conditions, a controllable drainage system can also be used for underwatering. The technique simply means that water is forced into the drainage system via the wells. Each well then has a float with a predetermined level that regulates the need for water supply. Underwatering can be an alternative watering technique to the above identified techniques where this is applicable. Underwatering can be applied to fields with many barriers and requires less work compared to conventional watering.

5.2 Experience from similar projects

SLU has carried out a number of projects and investigations regarding controlled drainage and underwatering.

Experience:

- In a project with field trials in Skåne and Kalmar[17] it is found that controlled drainage has major effects on soil runoff. On average, runoff decreased by 50%. The leaching of nutrients (N and P) also decreased significantly. Measurements of groundwater levels showed that, with the help of underwatering, it is possible to keep the levels up despite a large water shortage in the summer. Furthermore, it was shown that controlled drainage and underwatering have positive effects on harvest and N uptake in the crop. 6% - 10% increase in potatoes and 8% - 28% increased N uptake. 19% harvest increase on autumn wheat and 30% increased N uptake.
- Field trials with controlled drainage in Halland and Skåne [18] show the results that nitrogen leakage can be reduced by 20 to 30 kg N per hectare per year compared to traditional drainage.

5.3 Proposed definition – Customized drainage

Based on the above reviews, drainage is an important component for managing water on the fields and in the soil. The different methods have their advantages and disadvantages and also have limitations based on the physical conditions in place. The proposal to define the concept of customized drainage is therefore based on the ambition to use as much as possible of the surface water and nutrients that the recirculating irrigation and natural rainfall adds to a field:

"Customized drainage is a system consisting of one or more methods in combination that, based on the physical conditions in place, ***utilizes*** *most possible surface water and nutrients that the recirculating irrigation and natural precipitation provides for a field."*

5.4 Identified questions for continued work

The following questions have been identified and will try to be answered in the next part of the project - phase 2 Method development.

- ⇨ What components and functions can be included in a customized drainage system?
- ⇨ What ecological benefits, economic benefits and social benefits can be achieved through a system of customized drainage?
- ⇨ How is as much nutrition as possible returned to growing crops?
- ⇨ Where can traditional and controlled drainage and underwater irrigation be installed?
- ⇨ Design of traditional and controlled drainage as well as underwatering?
- ⇨ The benefit of traditional and controlled drainage and underwatering?

[17] Reglering av grundvattennivå i fält – underbevattning och reglerad dränering, slutrapport SLF, projektnummer 25-5234/01, Ingrid Wesström

[18] Wesström, I. 2002. Controlled drainage effects on subsurface runoffland and nitrogen flows. Swedish University of Agricultural Sciences. Agraria 350

6 Areas for next phase – Pilot project

This section presents proposals in areas within the catchment area of Tullstorpsån and within Högestad & Christinehof's fields with the right conditions for entering Phase 1 - Pilot project.

6.1 Selection criteria's

Based on the survey of the different functions for a multifunctional water reservoir above, the physical conditions in place, the landowners' wishes and focus on creating wetlands that especially has a water storage capacity with the possibility of irrigation withdrawals the below areas have been selected for future pilot projects. Full descriptions can be found in Appendix 2.

	Pilot project 1 Tullstorp stream - Jordberga Sugar mill dams	**Pilot project 2 Högesta Christinehof - Högestad**
description	Reconstruction of existing treatment ponds and cooling ponds (9 pcs), to multifunctional water reservoirs	Construction of a multifunctional water reservoir
wetland, ha	To be determined within the project	To be determined within the project
water surface, ha	6.5	5.6
average water depth, m	2-2.5	1.5
water volume, m^3	97 000	87 000
water resources (drainage, storm water, river water)	drainage water, storm water and river water	drainage water
basin, ha	To be determined within the project	250 of which 150 arable land
irrigation system	To be determined within the project	To be determined within the project
ha irrigated arable land	100	100
drainage	To be determined within the project	To be determined within the project
ha drained arable land	100	100
other	The project includes a landscaping of the area - restoring after the industry and creating a beautiful environment	To get to a wetland that becomes natural in the landscape, obtain biological values, work for nutrient purification and at the same time get a good volume of water it is proposed to make a dam system in two levels.

6.2 Pilot project 1

This project consists of existing ponds that were used for the former sugar mill that was located in Jordberga. This plant consists of 9 pcs. different dams that currently have quite different status. Some have a few decimetres of waste, some have a few meters of water and some have a lot of sediment in them. 7 of the ponds are completely square and two have a more natural design. Around the ponds there are also land areas that are not currently used or used for anything specific. The property is called Lilla Jordberga 4:20, Trelleborg municipality.

Overview map of the area. Farthest to the east is the Tullstorp stream.

For all dams, all scrap, plastic, concrete, electrical materials, etc. must first be removed. Everything should be sorted and removed from the area. Then all the ponds should be emptied of sediment. This sediment can be laid out in the area to shape and restore after the industry. Laying out the masses within the area allows you to adapt the landscape image and create a beautiful environment that can also be used such as for example pasture. There are large volumes of sediment to be moved around. This should not be a problem as the area is large. Since all the ridges are about 4 - 4.5 meters high and very steep, these should be lowered and the slope reversed. It is suggested that the embankments are lowered to about 2.5 - 3 meters in height and the slope is converted to a variation between 1: 3 to 1: 6. This means that the possible water volume will be about 2 - 2.5 meters average depth. Between the dams are made pits or pipes that allow the water to circulate throughout the system. This should be done so that the water goes from pond 1 to 9 and then possibly surplus drain into the Tullstorp stream. If larger volumes of water are needed, you should not lower the embankments so much, but adjust to the desired volume of water. Water supply can only be made by

pumping because the ponds 1 to 7 are at a high altitude. Pumping can be done from the Tullstorp stream and possibly from any drainage system that is nearby.

The water is pumped through electricity pumps that are powered by solar cells or regular mains power. This may be investigated in more detail. Withdrawal of water can only take place during periods of higher flows in the Tullstorp stream. This needs to be mapped to control how much water can be withdrawn and during what periods. The dams 8 and 9 have a fairly good design. The embankment located between the ponds and the Tullstorp stream is very high and should be lowered to get a better landscape adjustment. Otherwise, the technical structures should be replaced when in poor condition. Remove the inlet from the river because it does not perform any function. One possibility is to make an open stream as a transfer of water between ponds 7 and 8. This will create a varied and pleasant environment.

Systems for recirculating irrigation and controlled drainage are not designed.

6.3 Pilot project 2

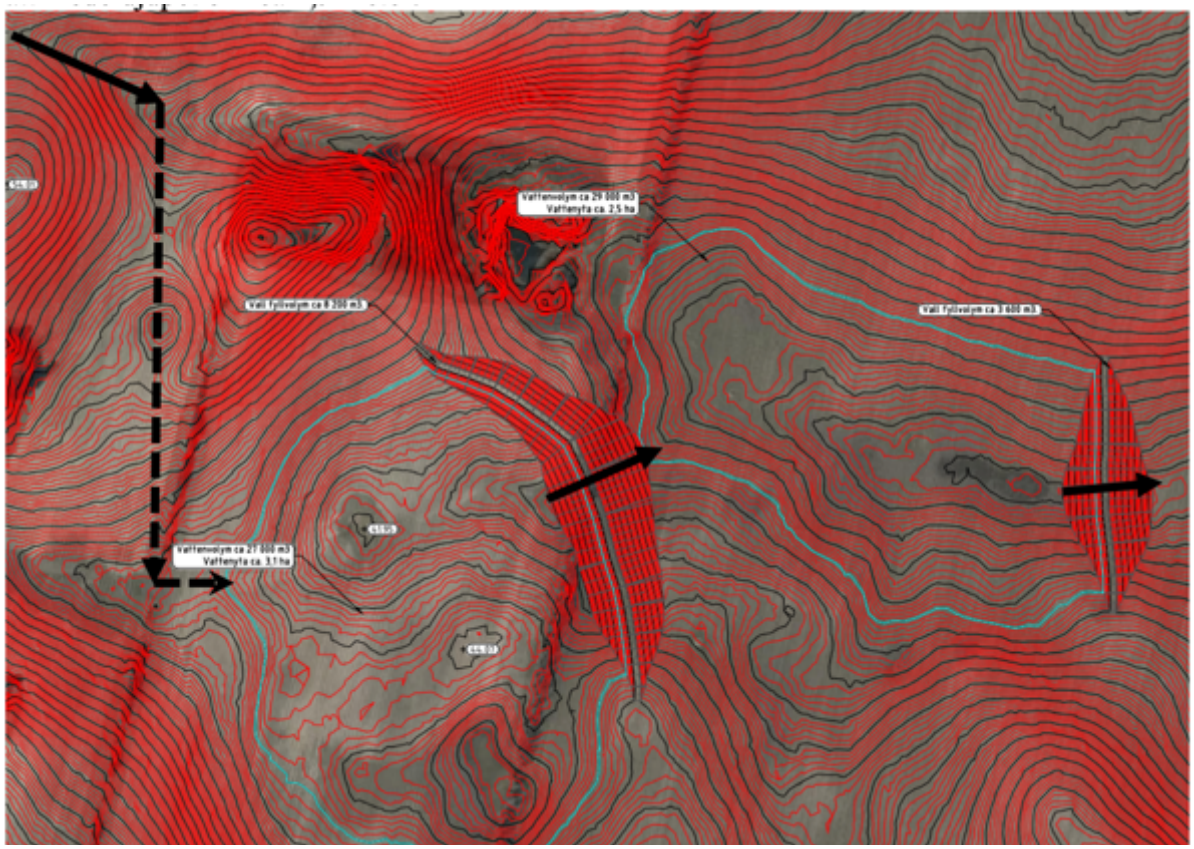
Högestad & Christinehofs Förvaltnings AB has pointed out an area where they would like to plant a wetland for irrigation. The irrigation should provide about 100 ha of arable land. The property where the wetland is to be built is called Högestad 36: 1, Ystad municipality.

Overview Högestad. Brown dash shows delimitation for irrigated area. Red ring shows the location of the wetland.

Water intended to be used comes from a closed drainage system with a catchment area of about 250 ha, of which 150 ha is arable land. The drainage system is not a drainage company and is wholly owned by Högestad & Christinehof Fideikommiss AB. The drainage system ends in Nybroån about 1.5 km from the planned wetland.

To get to a wetland that becomes natural in the landscape, obtain biological values, work for nutrient purification and at the same time get a good volume of water so it is proposed to make a plant on two levels. To get to these water surfaces it is necessary to make two fairly large ponds with a maximum height of about 3.5 meters. These dam walls are made with a slope of about 1: 6 and the material is taken within the area to be water surface to increase the volume of water. The shaft volume is about 12,000 m^3 needed for the embankments. To increase the volume, the soil of about 30 cm is laid off, which is laid out around the wetland on the arable land. Then some shafts are required for pipes, wells, electricity, etc. The water volume will be about 87,000 m^3 and the size will be 3.1 + 2.5 = 5.6 ha of water surface. This means that the average depth will be about 1.5 meters.

Systems for recirculating irrigation and controlled drainage are not designed.



Proposal sketch showing diversion of water (dashed line), embankments, water surfaces and placement.

6.4 Assessment of fulfilment of the definition of multifunctional water reservoir

The pilot projects are assessed below regarding fulfilment of the definition of multifunctional water reservoirs.

Purpose - WHY?

Pilot project	Purpose 1 main purpose	Purpose 2 subsidiary purpose	Purpose 3 subsidiary purpose			
1 Jordberga sugar mill dams Points 3 - 3 purposes	Water source for irrigation outlets	Nutritional treatment	Biodiversity			
2 Högesta & Christinehof Points 3 - 3 purposes	Water source for irrigation outlets	Nutritional treatment	Biodiversity			

Assessment matrix 1 - Purpose of the multifunctional water reservoir

Design - HOW?

Pilot project	Favours groundwater formation	Protects against drought - Water-holding capacity	Reduces flood risk - Flow equalization	Maintains biodiversity	Reduces eutrophication	Reduces climate impact
1 Jordberga sugar mill dams Score 10	Low Not high up in the water system and not on permeable soil. In addition, artificial ponds that will hold water	High Good opportunities to store large volumes of water	Low Limited as the water must be pumped from the river, can be increased to Medium depending on the amount of water that can be taken from drainage systems and stormwater systems	Average Good opportunities for rich wildlife in the two cooling water ponds. The landscaping of the other area is important	Average Limited as there are limited quantities of water that can pass through the system, however this is offset by the fact that it passes 9 different ponds	Low The wetlands are not on any old peat layer
2 Högesta & Christinehof Score 13	Low Not high up in the water system and not on permeable soil.	High Good opportunities to store large volumes of water, however important to ensure that the system does not release water downwards	High The wetlands are planted in a less closed drainage system and thus have good opportunity to balance the flow	Average Good opportunities for rich wildlife in both ponds. The landscaping of the other area is important	High The catchment area of about 250 ha consists of about 150 ha of arable land, all water must pass through the spring fields	Low The wetlands are not on any old peat layer

Assessment matrix 2 - Design of the multifunctional water reservoir
The design's ability to achieve the respective benefit / function is assessed in three levels - Low (1 point), Medium (2 points) and High (3 points).

Both pilot projects are expected to meet the criteria for multifunctional water reservoirs.

The matrix above is a first draft model for determining a project fulfillment of the definition of multifunctional water reservoirs. The model will be further developed in the next part of the project - phase 2 Method development with the aim of being able to be used as a basis for prioritizing financing support.

6.5 Assessment of fulfilment of the definitions Recirculating irrigation and customized drainage

The pilot projects are assessed below regarding fulfilment of the definitions of recirculating irrigation and customized drainage.

Return and use of water and nutrients?

Pilot project	**Quantity of surface water [m³] that is returned from the multifunctional water reservoir to growing crops**	**Amount of nitrogen [kg] and phosphorus [kg] which the systems are expected to contribute to nutrient purification**			
		Irrigation	**Conventional drainage**	**Controlled drainage**	**Under Irrigation**
1 Jordberga sugar mill dams	*Determined within the pilot project - depends on factors such as; storage volume, evaporation, supply of new surface water during irrigation season, etc.*	*For all systems, there is currently insufficient knowledge and experience to be able to determine a specific measure of the nutritional effect in general. It is our hope that in the future phases of the Tullstorp stream 2.0 project, together with research institutes, we will be able to make proposals for measures / levels for the nutritional cleansing effect for each system, which in turn can be used to make this model useful.*			
2 Högesta & Christinehof	*See above*	*See above*			

Assessment matrix – recirculating irrigation and customized drainage

Since the pilot projects final design yet not is fixed, we cannot assess how well the pilot projects fulfil the criteria's regarding recirculating irrigation and customized drainage.

The above model is a first draft for establishing a project fulfilment of the definitions of recirculating irrigation and customized drainage. The model will be further developed in the next part of the project - phase 2 Method development with the aim of being able to be used as a basis for prioritizing financing support for future projects.

7 Nature conservation and social benefit

This section highlights the concepts of nature conservation considerations and social benefits.

7.1 Nature conservation

Nature conservation considerations in wetland projects (requests from WWF)

7.1.1 Overview of relevant regulations for the project

The pre study includes an overview of the regulations that affect the construction of wetlands and the use of water in the project.

7.1.1.1 Different levels of testing

Different types of water activities require different types of testing and the limit for what testing is needed is not always clear. Test level is mainly due to local conditions, such as the competition there is on the water in the surrounding areas. Regardless of the trial level that is current for operating, operator needs to acquire knowledge of abstractions influence and to have a good self-control.

7.1.1.2 Notification

For some water activities - for example wetlands less than 5 hectares - it is sufficient to notify the operations to the County Administrative Board before it commences. Often, the notification is a fairly simple procedure, but if it turns out that the operation or withdrawal of water has a major impact, it can sometimes end with the County Administrative Board submitting the operation to apply for a permit. A notification does not provide legal security. If a complaint arises, the County Administrative Board may supervise and demand that the operation or withdrawal to be stopped.

7.1.1.3 Permission

The permit was formerly called “vattendom”. A permit is the only one that ensures water supply for a future irrigation on the fields. It gives the legal right to use the water according to the approved permit judgment. It is the Land and Environmental Court that authorizes water withdrawals, irrigation reservoirs and wetlands. A permit costs quite a lot, but several farmers can go together and apply for permits at the same time, and share the costs.

For surface water withdrawals, permits are always needed if withdrawals need to be made at boundaries other than guidelines developed by (Skåne and Blekinge), see below section. With regard to groundwater withdrawals, permits are always needed unless the outlet is obviously harmless.

7.1.1.4 Guidelines for water withdrawals for those who do not have a permit

When can you take water from watercourses if you do not have a permit? The county administrative boards in Skåne and Blekinge have decided on guidelines for irrigation withdrawal[4], which also applies to replenishment of wetlands and irrigation ponds. The rule is that flows must be higher than 30 percent of the annual average flow. The 30 percent limit is based on a general assessment of the risk of damage to fish, mussels, amphibians and other living organisms in the water. During the summer of 2018, the flow in most watercourses in Skåne was between one and five percent of the annual average flow.

7.1.2 Measures to strengthen the traditional functions of wetlands

The pre study also includes an analysis of possible activities to strengthen the wetlands' traditional functions such as nutrient trap, groundwater replenishment and to strengthen the biodiversity adjacent to the wetlands. Such measures may include the sowing of flowers to help pollinating insects, basins for frogs and insects, bird breeding habitat, and measures to ensure an ecological flow in the Tullstorp stream during periods of drought.

In the section above, different measures are identified and discussed that can strengthen the wetlands' traditional functions and also help a wetland to fulfil many different functions at the same time. The draft models above, assessing a project fulfilment of the definition of multifunctional water reservoirs, recirculation irrigation and customized drainage will be developed further in the next phases of the project - phase 2 Development of methods with the objective to be used as a basis for prioritizing funding support.

To strengthen the biodiversity in a wetland project, following advice (advice County Administrative Board of Skåne decision of wetlands) can be used:

- If islands are constructed, it should be done to a limited extent and with a height of not more than 10 cm above the expected water level. Islands should be positioned so that the water does not run the risk of being channelled. Flat islands that are given the opportunity to flood at high tide run less risk of growing again with bushes and shrubs, which increases their value for ground-nesting birds and reduces the need for maintenance.
- The slope of the coastal slopes should not be steeper than 1: 6; where meadow is necessary for the function of the plant, the slope of the slope on the outside should not be steeper than 1: 6. Flat beaches reduce the risk of accidents and benefit plant and animal life. Long beach zones can provide living space for several different species and increase the biodiversity of the area. Flat beaches also make it easier to maintain wetlands.
- Excess masses should be smoothed out smoothly and not put up in marked ridges or piles so as not to disturb the landscape.
- If shrubs, trees or aquatic plants will be planted, local varieties should be used by species naturally occurring in the area, as foreign species of shrubs, trees or aquatic plants may adversely affect the natural environment.

An interesting aspect that will be addressed in the next parts of the project is measures to ensure an ecological flow in the Tullstorp stream during periods of drought. In pilot project 1 on the Jordberga sugar mill dams, the plant that lifts water from the Tullstorp stream to the multifunctional wetland system will be designed so that a minimum flow is guaranteed in the Tullstorp stream. It will also be investigated whether the water reservoir that the wetland system stores can be used to return water to the Tullstorp stream during periods of extreme drought.

7.2 Social benefit

Strengthen the social benefits of wetland projects (requests from Region Skåne)

Chapter 9 - Results and discussion presents a matrix that shows the social benefits of proposed systems with the components of multifunctional water reservoirs, recirculating irrigation and customized drainage.

In phase 2 - Method development, in the work with guidance / manual, a method will be woven into studying the wetland project as a puzzle piece in the County Administrative Board's regional action plan for regional green infrastructure and present a comprehensive picture of a wetland project's "production" of ecosystem services linked to a monetary valuation of these.

In Phase 2 - Method development, in- depth work on the benefits of wetland projects will be carried out in the form of:

- A guide / description for the design and construction of systems for multifunctional water reservoirs and recirculating irrigation is produced.
- Development of working method / process to create a holistic view and enable a holistic approach to a body of water / watercourses to be made.
- The final result is compiled in a manual.

A guide / description for the design and construction of systems for multifunctional water reservoirs and recirculating irrigation is developed focusing on **technical** aspects:

⇨ design, planning and authorization process
⇨ construction and implementation
⇨ operation and maintenance

Development of working method / process to create a holistic view and enable a holistic approach to a body of water / watercourses to be done with focus on **process-** related aspects:

- ⇨ regulations affecting wetland construction and the use of water in recirculating systems
- ⇨ methodology for establishing a "water budget" for the water body / watercourse
- ⇨ links and collaboration with other processes / plans involving the water body / watercourse
- ⇨ environmental economic calculation or "production" of ecosystem services linked to monetary valuation - ecological benefit to the environment
- ⇨ socio-economic calculation - "economic" benefit to society
- ⇨ business-economic calculation - economic benefit for the landowner

8 Water budget – water balance

This section contains a discussion and a proposal for further work to develop a methodology for creating a water budget for the Tullstorp stream.

8.1 Water budget

There are many important stakeholders (agriculture, drinking water production, industries, natural values, hydropower etc.) around one and the same water system. Today, many interests claim the same water resource and are set against each other. It is becoming increasingly clear that there is no holistic approach to water issues.

Within the pre study of Tullstorp stream 2.0, Sweco has been asked to develop a description of how a water budget / water balance can be developed for the river / river basin.

Available river flow data have been compiled. In summary the below data is available:

- SMHI:s S-HYPE (modeled data)
- Flow measurements carried out in 2009/2010, within the framework of the Tullstorp stream project (actual flow measurements)
- Indirect flow measurements by water level measurements since 2011. Within the Tullstorp stream project water levels have been measured and flows calculated indirectly by using water level data as determined by flow measurements 2009/2010 (indirect flow measurement by water level measurement)

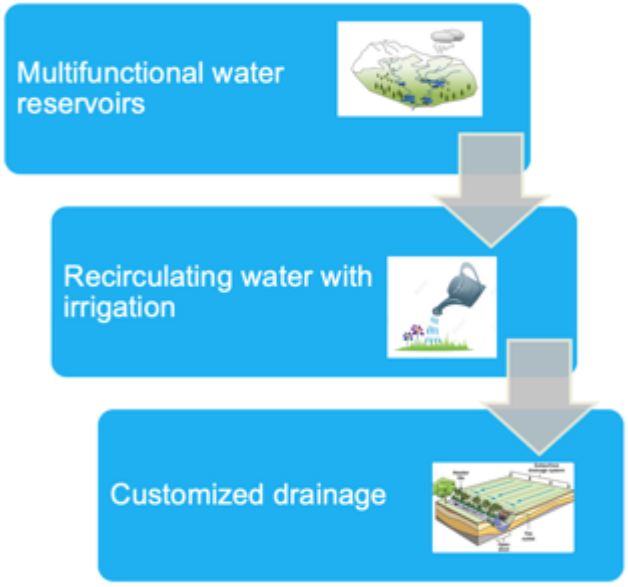
In order to be able to perform statistical analyzes of flow data and to generate characteristic flows, a longer data series is required than what is available in the measured data series, and these analyzes of sets are performed based on SMHI's modeled flows (S-HYPE). Correlation between measured and modeled flows will be analyzed in order to assess the reliability of the three data sets. SMHI's S-HYPE model is available for the entire catchment area. An analysis of the catchment area's topography and historical precipitation data will be made, to assess how the runoff varies within the basin.

An inventory of possible withdrawals from the river will be made (applies to licensed as well as non-licensed withdrawals).

Based on the above, a water budget for the river will be prepared.

9 Result and discussion

Historically executed and ongoing water projects (such as the Tullstorp stream project) have been created, designed, operated and followed up from a, largely, strictly ecological perspective with the goal of generating ecological benefits. If the perspective is broadened to allow future water projects to be run to achieve both ecological benefits for the environment, but at the same time economic benefits for the landowner as well as social benefits, there is a possibility that water projects will have a larger and broader impact. The basic idea of this project is water to be stored in multifunctional water reservoirs when there is excess of water. During drought water is "harvested" from the water storage and use in a recirculating irrigation systems and systems with appropriate drainage and finally, to a certain extent, returned to the water system. The result of the pre study shows that using a system of the combination of the three components - multifunctional water reservoirs, recirculating irrigation and customized drainage creates the opportunity to simultaneously achieve ecological benefit, economic benefit and social benefit in parallel.



	Ecological benefits	Economic benefit	Social benefit
Multifunctional water reservoir	The water reservoir contributes to many of the ecosystem services that a traditional wetland also does, but focuses on the benefits - water storage, flow smoothing and groundwater formation.	Water supply for the landowner	Management of water as more surface water is used as a water source, while agriculture achieve a better resistance to extreme periods of wet and dry through secure water supply
Recirculating irrigation	Nutrient purification by uptake in crops	Increased harvests and new crops	More food can be produced and new crops are introduced. Agriculture achieve a better resistance to extreme dry periods through irrigation
Customized drainage	Nutrient purification through uptake in crops and reduced risk of nutrient leakage through surface runoff. Better infiltration and soil structure help reduce the climate impact of cultivation per kilo of product.	Increased harvests and smooths growth	Agriculture achieve a better resistance to extreme periods of wet and dry by the fact that the soils opportunity to take up water at the intense and prolonged rains is improved and that the crops get better developed root systems

Matrix of ecological benefit, economic benefit and social benefit in a system with multifunctional water reservoirs, recirculating irrigation and customized drainage.

During the work with the pre study, it has been noted, in the dialogue with all participating parties, that:

- It requires many and urgent measures to mitigate the effects of climate change
- The types of measures proposed in the pre study are one way forward but more types of measures are needed
- Proposed measures are costly and today there are no forms of support to be able to build these types of systems
- There is a need for dissemination of knowledge and experience in planning and implementing proposed measures consisting of a system of different components
- Reference systems / pilot projects need to be established where research and evaluation can be linked to verify action effects

The challenge for the future also lies in the fact that there are many different authorities that need to work together to create opportunities for more climate-impact mitigation water projects to be done in the future.

10 Continuation of the project

The project's continuation is dependent on support from financiers. The next two phases - phase 1 Pilot project and phase 2 Method development is planned in detail with Project plan and Budget plan, see Appendix 1.

As the project spans several different areas that affect different authorities, it will be necessary to put together a panel of different financiers to be able to continue the project.

- The application for funding through LOVA was made in December 2019. In February, the answer is received that there is not enough money within LOVA to build the multifunctional water reservoirs. For recirculation irrigation and customized drainage, the County Administrative Board is unsure whether it is possible to use LOVA funds.
- Dialogue is done with co-financiers to the pre study, WWF and Region Skåne, about their possibility of co-financing the continued project.
- Dialogue with Jordberga Gård and Högestad & Christinehof about own efforts in parallel with contributions / support from suppliers of irrigation equipment.
- A dialogue has been initiated with the Swedish Environmental Protection Agency and the LIFE program on the possibility of continuing the project within the framework of this program.
- Environmental Protection Agency's Climate Step can be commented to be searched for improved energy efficiency and reduced CO^2 emissions through the choice of the best possible technology for irrigation.
- Other authorities and organizations such as the Swedish Board of Agriculture, SLU, SGU and Lund University of Technology have been contacted and a dialogue has begun.
- The goal is to connect additional co-financiers to ultimately secure the project's continuation.

11 Financial reporting

The funding from the financiers have been used according to below overview:

Budget	2019/2020		Utfall Q3 2019	Utfall Q4 2019	Utfall Q1 2020	Utfall Q2 2020
Projektledare, arbete och rapport - förstudie	240 000		63 000	63 000		147 372
Underlag Högestad	25 000			8 314		
Underlag Tullstorpsån	25 000			8 314		
	290 000		**63 000**	**79 628**	**0**	**147 372**
Medfinansiering						
WWF	125 000	43%			**Budget**	**290 000**
Region Skåne	125 000	43%			**Utfall**	**290 000**
LOVA	40 000	14%				
Totalt	**290 000**					

12 Annexes

Appendix 1
Project description TEF Subproject 2 – Tullstorp stream 2.0 Pilot project & Method development FINAL 2019-11-27 CB
(reported in separate document)

Appendix 2
NVI PM technology and costs 2019-11-13
(included as annex in the above document)