ENVIRONMENTAL AND AGRICULTURAL PROTECTION BY CREATING TEN IRRIGATION RESERVOIRS IN THE AUTIZES

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ABSTRACT

The Marais Poitevin is a 970 km² marshland in Western France. Two thirds of the marsh (the dry marsh) is used for farming and breeding. One third of the marsh (the wet marsh) is a maze of islets criss-crossed by canals nicknamed The Green Venice. This wet marsh is an important place for biodiversity (birds, fish, plants..). Although the area was declared a Regional Natural Park in 1979, it lost that status in 1997 as intensive agricultural development around the Marsh endangered its natural biodiversity. Cereal and corn cultures need big quantities of water during dry season and the intensive water pumping was lowering down the water level of the marsh and endangering its existence. In order to preserve the agricultural economy of the region and its unique natural environment, it was decided in 2006 to built 10 artificial irrigation reservoirs upstream of the marshland in order to store 3,2 million m³ of water during the wet season when there is an excess of water and use it during the dry season to irrigate the cereals and corn. In parallel, a collective and equitable management of water pumping was established. This 16 million € (Euro) project took place between 2006 and 2010. Nine of those 10 water reservoirs have been made watertight using an EPDM (Ethylene Propylene Diene Terpolymer) geomembrane 1,1 mm (460.000 m²). EPDM geomembrane was chosen for its long durability and fast installation process. The project is too recent to already draw any conclusion but first results are very encouraging as a positive impact on the water table level during the dry season has been measured. This case study presents the use of geosynthetics for biodiversity and agricultural protection and the step by step construction of a water reservoir made watertight with a synthetic liner.

Keywords: Water reservoir, EPDM, geomembrane, waterproofing, water conservation

INTRODUCTION

This case study presents the use of geosynthetics as a solution for environmental and agricultural protection in the Marais Poitevin. After introducing the unique environment of this huge marshland and the reasons why this area is endangered by intensive agriculture, the implemented solutions in the Autizes to reduce the impact of irrigation on the marsh while maintaining farming economically viable will be presented. Finally, we will review the different construction steps of an EPDM (Ethylene Propylene Diene Terpolymer) geomembrane lined irrigation reservoir and the first results.

THE MARSHLAND

With a surface of nearly 100.000 ha, the Marais Poitevin (Fig. 1) is the second biggest marshland in France.

Fig. 1 Areal view of the Marais Poitevin

Located in Western France (Fig. 2), the Marais Poitevin is a very valuable and fragile ecological area. It is home to a large number of remarkable and diversified plants (over 750 species) and animals (250 bird species, 50 different mammals, 38 kinds of fish,…). It also plays an important economic role for activities like agriculture, tourism, shellfish farming and fishing.

Fig. 2 Location of the Marais Poitevin

The Marais Poitevin is composed of two main ecological and landscape entities related to its hydraulic characteristics: the wet and the dry marsh.

The wet marsh (1/3 of the surface) is the most famous part of the Marais Poitevin. Partly classified as Grand Site de France, this area includes the famous Green Venice. This protected area is crossed by a maze of canals bordered by rows of trees that stabilize the banks (Fig. 3). With 850.000 tourists per year the wet marsh is an important European ecotourism destination (Fig. 4). In the wet marsh, the agricultural activity is mainly livestock (Fig. 5).

Fig. 3 Canal of the wet marsh

Fig. 4 Ecotourism attraction of the wet marsh

Fig. 5 Livestock breeding in the wet marsh

In the Middle Ages, the dry marsh has been artificially protected from flooding so as to allow agriculture. Nowadays, big open land surfaces are dedicated to farming and breeding (Fig. 6).

Fig. 6 Cultures in the dry marsh

ENDANGERING THE MARSHLAND

In the eighties, as a result of the increase in cereal crops and corn (for economical reasons), the irrigation has strongly increased around the marsh . Water pumping was done from rivers, marsh canals and mainly from underground water tables. Pumping was so intense that during the dry season (summer), the level of the water table was lower than the water level of marsh canals. The marsh canals were draining into the water table when it should be the opposite. The marsh was drying out, endangering its ecological balance (Ouvrard, 2012). In 1997, the wet marsh lost its status of Regional Natural Park it held since 1979.

It was therefore decided that all irrigation pumping had to stop when the water table reached a defined critical piezometric level (equivalent to the water level balance between the water table and the marsh). Despite this restrictive measure, the marsh was still too dry in summer and the farmers couldn't irrigate at the most critical moments.

IMPLEMENTED SOLUTIONS

The Marais Poitevin is linked to several drainage basin, one of them being called Autizes (affecting 1/5 of the marsh). In the Autizes it has been decided in the year 2000 to reduce the irrigation demand on the marsh by reducing pumped volumes and regulating pumping periods.

For the entire Autizes drainage basin, it was determined that in a normal year (reference was 2004) the 117 farmers needed 8 millions m³ of water for irrigation. The decision was taken to reduce this reference volume by 20 %. 50 % of the remaining volume (3,2 millions m³) is to be pumped during the dry season, the other 50 % during the raining season (winter) and stocked into 10 irrigation reservoirs.

With this solution, during the dry season, when the demand on the water table is the highest, the pumping is reduced by 60 %. But at the same time, the farmers have a safer water supply as there is less risk of reaching the critical piezometric level.

In the past, farmers had a yearly allocated volume of water and were free to use it whenever they wanted until the critical piezometric level was reached. Now, pumped volumes are managed collectively and are linked to piezometric measurements, water flow in rivers and water level in marsh canals (Lepercq and Laloux, 2011). At the start of each irrigation season, the 117 farmers (even those that are not connected to the reservoirs) have to decide, depending on their crop rotation, the distribution of their allocated volume of water for the entire season. During the irrigation season, a management committee meets every 2 weeks to adapt the forecasted water volumes for the next 2 weeks according to the measured piezometric levels. They make sure not to reach the critical piezometric level.

An independent company has been hired to control that the farmers respect their allowed pumping volumes.

The acceptance by farmers of the pumping restrictions and cost increase has been greatly facilitated by their involvement into the decision making process and the security of water supply throughout the entire irrigation season. The sense of responsibility of the farmers has risen sharply.

TEN IRRIGATION RESERVOIRS

In 2006 it was decided to built 10 artificial irrigation reservoirs into the Autizes drainage basin, upstream of the marshland (Fig. 7), in order to store 3,2 millions m³ of water.

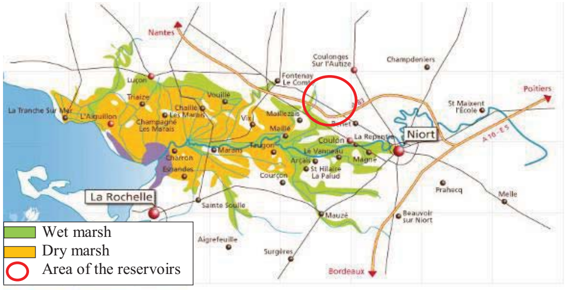


Fig. 7 Location of the irrigation reservoirs

This 16 million € (Euro) project was funded with 85 % of public money and 15 % by the farmers themselves as a 12 year loan, repaid per m³ of water used.

The construction of the irrigation reservoirs took place between 2006 and 2010. The capacity of the reservoirs varies from 140.000 m³ to 650.000 m³. One reservoir was constructed in natural clay. The other nine have been artificially made watertight with an EPDM geomembrane 1,1 mm as the natural ground was permeable (Fig. 8 and 9).

Fig. 8 Saint Pierre le Vieux – 485.000 m³ - 2006

Fig. 9 Oulmes Sud – 200.000 m³ - 2010

At the end, it is 460.000 m² of EPDM geomembrane that was installed in this project. EPDM geomembrane was chosen for its long durability and fast installation process.

EPDM geomembrane is an elastomeric synthetic rubber membrane made by combining Ethylene, Propylene and Diene monomers to form a chemically saturated (no double bonds) backbone providing excellent heat, oxidation, ozone and weather aging resistance. The individual polymer chains are cross linked together during the vulcanisation process, generating a 3 dimensional network and giving an elastic behaviour with over 300 % of elongation. EPDM geomembrane can withstand important hydrostatic pressure and has very good puncture resistance over time (Blanco et al., 2011).

Installation process of EPDM geomembrane is made easy because of its flexibility and the large panel sizes (15,25 m x 61,0 m). The 930 m² panels allow for significant reduction in the number of seams to be carried out on site and considerably reduces the installation risks.

STEP BY STEP CONSTRUCTION

The 9 irrigation reservoirs where an EPDM geomembrane was used are located on a limestone plain. They are built using the excavation and backfilling technique.

The limestone rocks are broken and crushed at the bed of the reservoir and the excavated ground is loaded onto trucks (Fig. 10 to Fig. **14**).

Fig. 10 Site before starting the excavations

Fig. 11 Rock breaking at the base of the pond

Fig. 12 Hydraulic rock breaker

Fig. 13 Rock crusher

Fig. 14 Excavation of the base of the pond and truck loading

Trucks unload the excavated ground at the top of the embankment were it is leveled and compacted layer by layer. Compaction is done in order to reach the 95% of the Proctor Optimum value (Fig. 15 to Fig. 18).

Fig. 15 Unloading of excavated ground on the embankments

Fig. 16 Leveling with bulldozer on the embankments

Fig. 16 Compaction of the embankments with chevron tamping wheels compactor

Fig. 17 Measurement of the degree of compaction

Fig. 18 Embankment before final finishing

The support structure of the geosynthetic is made smooth and free from aggressive stones with a stone crusher and smooth drum roller compactor (Fig. 19 toFig. 21).

Fig. 19 Stone crusher

Fig. 20 Final compaction

Fig. 21 Support layer overview

The external embankment is protected from erosion by means of a layer of topsoil seeded with grass (Fig. 22).

Fig. 22 External embankment (before and after seeding)

The outlet and water drainage pipes going through the embankment are covered with concrete for protection and to avoid piping phenomena (Fig. 23).

Fig. 23 Outlet and water drainage pipes through the embankment

The outlet pipe is embedded in a concrete block constructed in such a way so as to limit differential settlements and present a smooth surface for mechanical anchoring of the geomembrane (Fig. 24).

Fig. 24 Water outlet pipe at the bottom

The water drainage system installed below the geomembrane will collect underground water and the water coming from an eventual leakage in the lining system. A drainage pipe is installed inside a trench with gravel and a filtration geotextile (Fig. 25 and 26).

Fig. 25 Water drainage ditch

Fig. 26 Water drainage outlet

A gas drainage system is installed under the geomembrane to avoid any uplift pressure caused by the raising of the underground water table. The drainage géocomposites are made of 2 layers of filtration geotextile with a high density polyethylene geonet in the middle (55 cm large and 6 mm thick). The drainage geocomposite is connected to vents positioned on the crest of the embankment (Fig. 27 and 28).

Fig. 27 Gas drainage with geocomposite

Fig. 28 Gas vent at the top of the embankment

A puncture resistant geotextile is installed between the substrate and the geomembrane. The 400 g/m² Asqual (French quality certificate) certified geotextile is made of 100 % polypropylene non woven, needle punched, short fibers. The different geotextile panels are hot welded together in order to avoid any movement while installing the geomembrane (Fig. 29).

Fig. 29 Geotextile installation

The Asqual-certified EPDM geomembrane 1,1 mm panels are positioned at the top of the embankments according to a pre-defined layout plan. The geomembrane is then unrolled and unfolded. The different panels are seamed together by Asqual-certified contractors using a self-adhesive EPDM/butyl tape and primer (Fig. 30 to 33).

In order to have a better control on installation progress, some installers decided to pre-assemble the geomembrane in a warehouse and bring on site panels of nearly 2000 m².

Fig. 30 Unrolling of EPDM geomembrane

Fig. 31 Unfolding of EPDM geomembrane

Fig. 32 Seaming of EPDM geomembrane

Fig. 33 Installed EPDM geomembrane

The geotextile and the geomembrane are anchored at the top of the embankment in an anchor trench. After installing the geosynthetics, the anchor trench is backfilled and compacted without subjecting the geomembrane to stress.

Fig. 34 Anchor trench with geotextile

Fig. 35 Anchor trench after back filling

In order to prevent an overflow of the reservoir a designed spillway is installed in the sidewall (Fig. 36).

Fig. 36 Pipe spillway

In order to avoid wind uplift, 5-6 m long PE bags, filled with gravel, are coming from the top of the embankment and anchored on the crest (Fig. 37).

Fig. 37 Wind ballast with PE bags filled with gravel and anchored on the crest

Some reservoirs that can be exposed to strong winds require an extra protection of the crest against waves overflow. It is a small seeded mound of ground protected with an anti-erosion geotextile (Fig. 38).

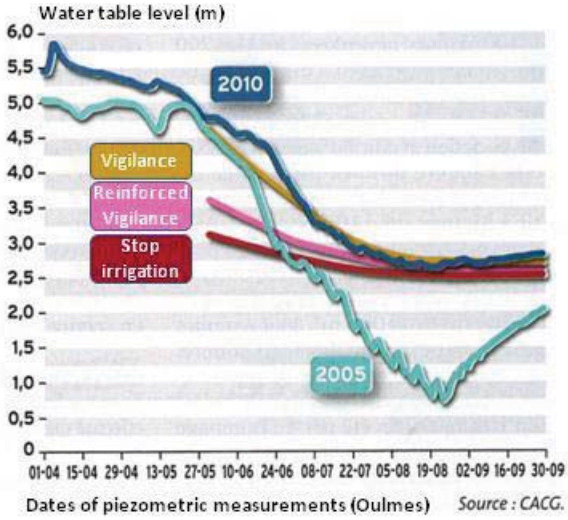
Fig. 38 Waves protection

During the entire installation a strict internal and external control process is implemented on delivered materials and installation quality (Fig. 39).

Fig. 39 Quality control with vacuum chamber

PROMISSING RESULTS

As the last irrigation reservoir was only finished in 2010, there is little feedback to evaluate the real impact of the project. Nevertheless, some preliminary results have been observed. In 2009 (with 7 reservoirs), the critical piezometric level was not reached. In 2010 (7 reservoirs), rainfall has been as poor as in 2005 (0 reservoirs). In 2010, with 7 reservoirs, the minimum water table level was 1,9 m higher than in 2005 (Fig. 40) and the minimum water level in the main marsh canal (situated downstream) was 0,2 m higher with a delayed drop of one month.



Source : CACG.

Fig. 40 Water table levels in 2005 and 2010

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