Summary

As water is becoming more and more important, proper water management is required to improve the efficiency of water systems. Research on irrigation canals by using automatic control are being performed by water management department of Delft University of Technology for a long time. Many classical Feedforward and Feedback controllers have already been designed and applied to control water levels and flows in multiple canal reaches. Now a more advanced control technique, Model Predictive Control (MPC), is researched for the application, which can deal with the constraints of the system. This thesis is based on this framework of MPC.

Model Predictive Control (MPC) is a practical model based control technique which emerged from the chemical process industry in the 70's. It is regarded as an advanced control not only because of its use of feedforward and feedback control to the system as well, but also because it takes all the control objectives and constraints into account and applies optimizations techniques. All the MPC have 4 components:

- The internal model: it is used to predict the future states of a controlled water system.
- The objective function: it is the formulation of goals that need to be achieved by the controller.
- The constraints: they are physical and operational limitations on the controlled water system.
- The optimization: it is a certain mathematical algorithm to achieve the goals by minimizing or maximizing the objective function.

Two linearized models are researched in this thesis, which are the time-invariant Integrator Delay (ID) model and the time-variant Saint Venant model. The ID model captures the main properties of the canal, delay time and surface area, while the Saint Venant model simulates the whole characteristics and its advantage is that the change of flow does not influence the internal model, only determined by the spatial discretization. They are both applied to the Central Main Canal in Eloy, Arizona, but it turns out that the ID model is more suitable for the application and implementation, considering the balance of accuracy and the computational time. It can optimize the water level errors and distribute the water properly for the prescheduled water order with a control step of two minutes. In theory, the Saint Venant model is supposed to be more accurate, due to the more dynamics simulated. But the results do not meet the expectation and its application is restricted. The reason comes that the flat water level profile weakens the connections between two adjacent segments according to the internal model, and then the optimization does not have enough relevant information to correct the water level deviations downstream. Thus, when deviation happens downstream, upstream structures can not efficiently deal with the situation due to the weak connection to the downstream water levels. This explains why more water is retained upstream. In addition, the computational time is another big restriction to its application. Therefore, more research is necessary for better internal models.