Conclusions

The simulations developed so far indicate that it is possible to produce small artificial flooding downstream of Irapé dam for reservoir releases as low as 600 m^3/s, which could potentially contribute to improve fish spawning areas and restore fish population in the river. By combining hydrodynamic river modeling and GIS processing, the location of the ponds can be identified and the resulting costs to the river users estimated based on current land use. This information can be used by an optimization model to help identify minimum cost water operations that are still able to meet environmental flow criteria, also providing support to the creation of economic compensation policies to river users.

Aknowlegdments

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References

ACREMAN, M.; DUNBAR, M.J. Defining environmental flow requirements – a review. Hydrology and Earth System Sciences. 8(5). Pp. 861-876. (2004).

BANDEIRA, A.P.F.; MENDES, C.A. Metodologia de otimização da exploração econômica de carvão mineral em bacias hidrográficas. XXVI ENEGEP - Fortaleza, CE, Brasil, 2006

BENETTI, A. D.; LANNA, A. E.; COBALCHINI, M. S. Metodologias para determinação de vazões aproveitamentos hidrelétricos – estudo de caso. Anais do XV Simpósio Brasileiro de Recursos Hídricos. Curitiba. 200
COLLISCHONN, W.; AGRA, S.G.; FREITAS, G.K.; PRIANTE, G.R. Da vazão Ecológica ao Hidrograma Ecológico. 2005.

Comitê Brasileiro de Barragens – CBDB. (http://www.cbdb.org.br/site/index.asp). Acesso em 20/09/2007. 2007.

GILLIG, D., McCarl, B. A., and Boadu, F. (2001). "An Economic, Hydrologic, and Environmental Assessment of Water Management Alternative Plans for the South Central Texas Region." Journal of Agricultural and Applied Economics, 33(1), 59-78. 2001.

GILLIG, D., McCarl, B. A., Jones, L. L., and Boadu, F. (2004). "Economic Efficiency and Cost Implications of Habitat Conservation: An Example in the Context of the Water Resources Research, 40(4), W04102, Edwards Aquifer Region." doi:10.1029/2003WR002749. 2001.

GONÇALVES, M.A., KOIDE, S., E CORDEIRO NETTO, O.M. Revisão e aplicação de alguns métodos para determinação de vazão mínima garantida em cursos d'água. XV Simpósio Brasileiro de Recursos Hídricos. CD-ROM. Curitiba. 2003

MARQUES, M. G.; MARTINEZ, C. B.; CANELLAS, A.V. B.; PANTE, A. R.; TEIXEIRA, E. D. Influência dos métodos de determinação da vazão ecológica no custo de geração de energia em aproveitamentos hidrelétricos – estudo de caso. Anais do XV Simpósio Brasileiro de Recursos Hídricos. Curitiba. PR. 2003.

OPERADOR NACIONAL DO SISTEMA ELÉTRICO – ONS. Inventário das restrições operativas hidráulicas dos aproveitamentos hidrelétricos. ONS, Diretoria de Planejamento e Programação da Operação. RE 3/144/2007, revisão 2 de 2007. 2007.

PELISSARI, V. B.; SARMENTO, R.; TEIXEIRA, R. L. Índices de preferência de habitat para peixes na determinação da vazão residual do rio Timbuí. Anais: XIII Simpósio Brasileiro de Recursos Hídricos. ABRH: Belo Horizonte, MG. 1999.

REIS, A.A.. Estudo comparativo, aplicação e definição de metodologias apropriadas para a determinação de vazão ecológica na bacia do rio Pará, em Minas Gerais. 2007. 170 f. Dissertação (Mestrado em Saneamento, Meio Ambiente e Recursos Hídricos) – Escola de engenharia da Universidade Federal de Minas Gerais, Belo Horizonte, 2007.

SANTOS, A.H.M., RIBEIRO JUNIOR, L.U., GARCIA, M.A.R.A., E SEVERI, M.A. 2003b. Vazão remanescente no trecho de vazão reduzida de pequenas centrais hidrelétricas. XV Simpósio Brasileiro de Recursos Hídricos. CD-ROM. Curitiba.
SARMEMNTO, R. Estado da Arte da vazão ecológica no Brasil e no mundo. Produto 2. Edital n. 05 do ano de 2006, PROJETO 704BRA2041 da Organização das Nações Unidas para a Educação, a Ciência e a Cultura – UNESCO/ANA/CBHSF. 2007.

THARME, R.E. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. River research and applications. N. 19, pp. 397-441. (2003).

YANG, Z.F.; SUN, T.; CUI, B.S.; CHEN, B.; CHEN, G.Q. Environmental flow requirements for integrated water resources allocation in the Yellow River Basin, China. Communications in nonlinear science and numerical simulation. N. 14, pp. 2469-2481. 2009.

The Unique Components of the West Branch Wetland Restoration Area – DuPage County, Illinois

Jedd M. Anderson[1]

[1] Christopher B. Burke Engineering, Ltd, 9575 West Higgins Road, Suite 600, Rosemont, IL 60018; PH (847) 823-0500; FAX (847) 823-0520; email: janderson@cbbel.com

Abstract

There have been many wetland mitigation and restoration projects completed over the years, but very few have as many unique aspects as this particular project or have been as complicated in terms of design, permitting and construction. Located in northeastern Illinois in western DuPage County, the West Branch Forest Preserve (WBFP) is a 811 acre preserve that contains several miles of walking paths, three fishing lakes that were once quarries and 1.6 miles of the West Branch DuPage River. The preserve is located in a well defined U-shaped valley formed during the last glacial period. The northern third of the preserve consists of the main parking area, river, the lakes, forest and some old fields. To the south are approximately 350 acres consisting of old agricultural field, floodplain forest, forest, wet prairie, scrub shrub and remnant fen habitats. Design of this project required the development of many unique and creative solutions to achieve project goals of wetland creation and restoration, habitat improvement and river restoration.

Following input from various stakeholders the design contains the following elements: Over 350 acres restored to native habitat; of which approximately 140 acres of wetland created and enhanced, including rehydration of a 25 acre remnant hillside fen. The hydrologic restoration of the wetlands is driven by disabling the extensive field tile system and re-infiltration of surface water. Additionally the project includes the restoration of 6,000' of the West Branch DuPage River to raise the base flow elevation to re-access the historic flood plain, and nearly 100 acres of tree and brush removal (mainly buckthorn and other non-natives); and implementation of a 10 year management and monitoring program.

West Branch Wetland Restoration Area - DuPage County, Illinois

Background

The West Branch Forest Preserve (WBFP) is owned by the Forest Preserve District of DuPage County, Illinois. DuPage County is west of the City of Chicago and Cook County. The WBFP encompasses a total area of 811 acres, and was originally purchased to help with flood control. The Preserve contains three lakes, 1.6 miles of walking and biking trails, wetlands, old field (remnant farm field), wet prairie, immature floodplain forest, and a fen. Overall the preserve is dominated by invasive pioneer and/or non-native vegetation that established following the cessation of farming. The preserve hosts a variety of reptiles, amphibians, mammals, and numerous species of birds, including grassland birds and

migrating and nesting shorebirds. Additionally, the preserve is essentially split in half on a north south axis by the West Branch DuPage River.

This project was initially conceived as a result of expansion plans for O'Hare International Airport, called the O'Hare Modernization Program (OMP). A portion of the Airport is located within DuPage County. Under the DuPage County Stormwater and Flood Plain Ordinance wetland impacts that occur in the County must be mitigated within the County. It was determined in 2003 that mitigation would have to be provided within DuPage County. Based on the area of wetland impacted, 90 acres of wetland would have to be created.

In November 2001, prior to the OMP project, DuPage County and the Forest Preserve District entered into an Intergovernmental Agreement (IGA) that allowed wetland mitigation to be created within District properties. Because the IGA was in place, stakeholders agreed that a search of District properties would be completed by OMP to locate suitable locations for the creation of at least 90 acres of wetland. Through a comprehensive site section process and alternative sites analysis, the West Branch Forest Preserve was selected from 18 sites originally considered. This site was chosen because it had the highest likelihood of success, could generate a large number of mitigation credits, allow all of the mitigation to be completed on one site reducing costs, as compared to using multiple sites.

Numerous meetings with the many stakeholder groups were held to discuss design concepts and to brainstorm on many design elements. Stakeholders included DuPage County, Forest Preserve District of DuPage County, Federal Aviation Administration, US Army Corps of Engineers, US Environmental Protection Agency, Illinois Environmental Protection Agency, Illinois Department of Natural Resources, and US Fish and Wildlife Service.

Because OMP was not party to the intergovernmental agreement OMP purchased wetland mitigation credits from DuPage County and the County became responsible for design, permitting, construction, management and monitoring of the created wetland areas through acceptance. In 2005 OMP made a payment to DuPage County satisfying their DuPage County mitigation obligations.

Christopher B. Burke Engineering, Ltd. was then hired by DuPage County to prepare the final wetland mitigation plans, and subsequently contracted by the Forest Preserve District to design and permit the non-mitigation components of the overall preserve and river restoration project. A detailed discussion of the overall project follows.

As mentioned above, this project must provide wetland mitigation but also meet the needs of the Forest Preserve District. The District took a holistic view of this project. The County only needed to create wetland to meet the mitigation needs. However, wetland creation is only one component of overall Preserve goals. Since the wetland creation obviously would bring an intrusion into the Preserve, the preference was to only complete that intrusion once; meaning that restoration of that entire southern portion of the preserve would be completed. Consequently, a contract was established by both agencies to fund the design of their respective project components.

DuPage County would be responsible for areas designated for wetland creation and restoration, wetland buffer and a portion of the river restoration, along with tree and brush removal within those areas. The District would be responsible for restoration of the fen, river and upland prairie restoration and tree and brush removal in the non-wetland and buffer areas.

The final design contains the following design elements:

- Over 340 acres of the Preserve will be restored to Native Habitat
- Approximately 140 acres of wetland will be restored and enhanced on site
- This restoration will be driven by disabling the extensive field tile drainage system and restoration of the West Branch DuPage River
- Very minor grading to fill in incised ditches and drainageways will be completed to allow for improved hydrology of large areas of the floodplain to improve habitat potential
- Approximately 37 acres of degraded wetland habitat will be enhanced
- Within the 140 acres of wetland to be restored on site are approximately 25 acres of historically field tile drained remnant fen which will be restored
- Approximately 10,000' of the West Branch DuPage River shoreline will undergo restoration. In-stream enhancements (riffles) will be installed to improve habitat and to raise the base flow elevation to a pre-settlement elevation to improve the flood plain hydrology.
- Nearly 100 acres of tree and brush removal (mainly buckthorn and other non-natives) will occur.
- The 350 acre work area will undergo a 10 year management and monitoring to restore the entire area to a native dominated area.

Existing Condition and Proposed Plan

The project site is located in a "U" shaped valley with a broad flood plain as illustrated in Figure 1 which is an aerial photo with topographic survey overlay. As shown in Figure 2, the site is characterized by old field and scrub vegetation away from the river and emergent wetland and riparian/floodplain forest adjacent to the river.

The remnant fen, (a hillside/valley wall spring fed wetland) located in the southwest quadrant along the valley wall, is dominated by non-native buckthorn (Rhamnus cathartica) and invasive box elder (Acer negundo). The fen has very little undergrowth due to shade suppression and alleopathic tendencies associated with buckthorn.

Figure 1

The flood plain area is generally gently sloping, has occasional shallow depressional areas. The entire site is extensively field tiled including the remnant fen. The field tiles have artificially lowered the groundwater surface elevation throughout. Even though the majority of the old field is a gently sloping hillside, there are extensive hydric soils throughout the area. Because the hydric soils formed in historically wetland conditions, we believe the field tiles have had a significant impact and caused a reduction in total wetland/fen surface area. This opinion is supported by the results of the groundwater monitoring. Abandonment of the tiles will allow the groundwater elevations to rise, subsequently rehydrating the hydric soils and allow for the re-establishment of wetland hydrology and subsequently the vegetation.

Additionally, the West Branch DuPage River is located in an incised channel that passes through the middle of the study area. The channel is acting as a sump to the surrounding flood plain. Not only does the incision assist the field tile drainage by allowing a positive discharge, it allows free ground water movement into the channel.

Figure 2

The channel historically was a shallow channel or swale that passed through a large wet prairie. Portions of the remnant channel still exist in the northeast quadrant of the site. When the channel was straightened the remnant meanders to the east of the channel remained intact.

Therefore not only would the field tiles be disabled, but the entire river bed within the channel would be raised through the creation of a series of pools and riffles. These features would raise the streambed approximately 2.5'.

Raising the streambed floods any remaining field tiles while allowing the river to flood out of bank more frequently, and also allow flood water to re-access the historic river channel to improve water movement throughout the east side wetland restoration areas.

Unique Project Components

There have been many wetland mitigation and restoration projects completed over the years, but very few have as many unique aspects as this particular project or have been as complicated in terms of design permitting and construction. The following will discuss each of the unique project components.

Wetland Rehydration

Surrounding the property are existing farm fields and subdivisions. These land uses discharge water from pipes as point sources or were connected to the field tile drainage system. Consequently, water either by-passed the site on its way to the river in pipe, or at several locations, in eroded incised ditches. This is the very water

needed to promote wetland rehydration. There was one obvious typical design solution; daylight the field tiles and allow runoff to flow overland. However, we knew from walking and studying the site that because the site is gently sloping, that

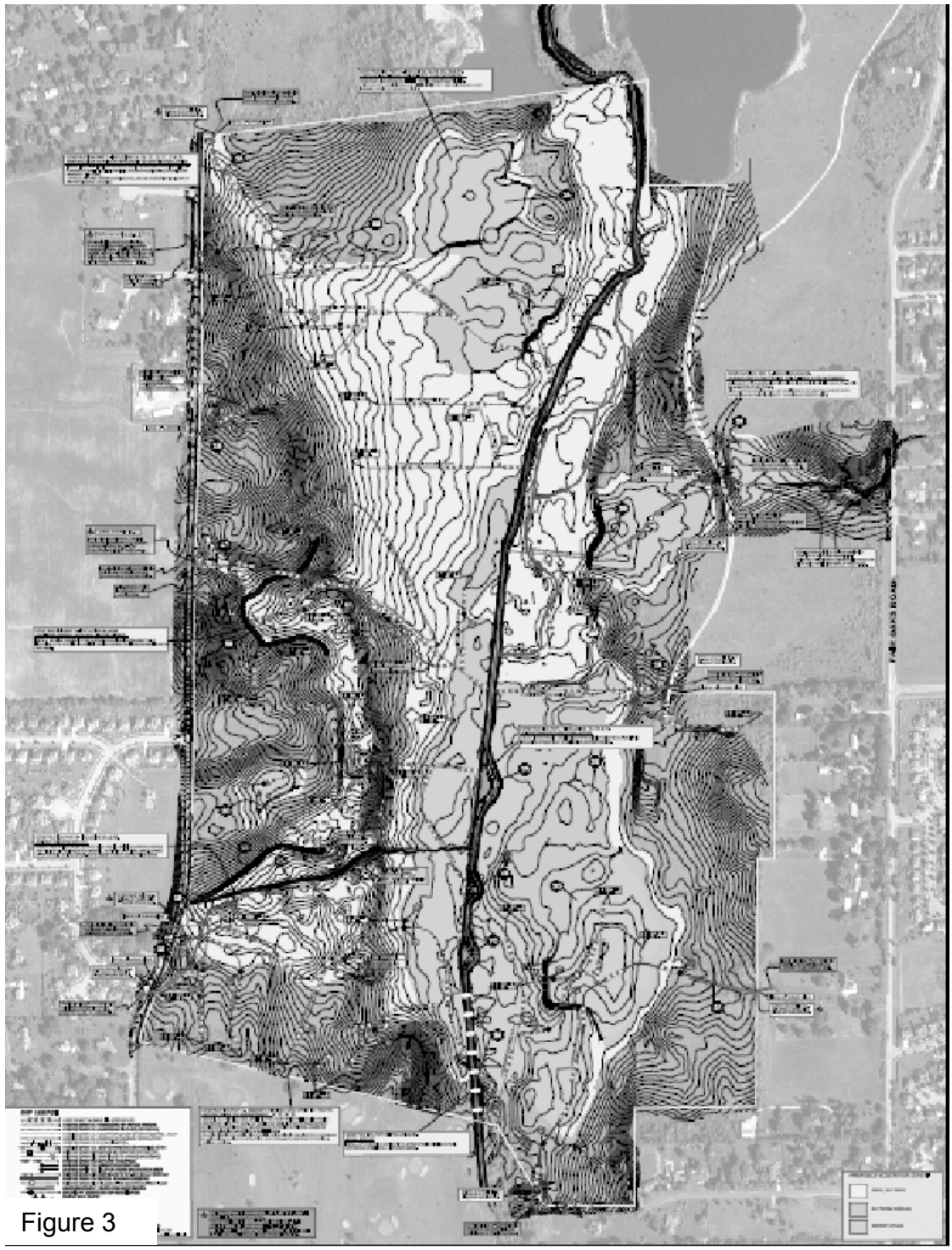

Figure 3

surface water would drain across the extensive hydric soils, likely in concentrated flow causing narrow drainageways and new erosional ruts to form.

Evidence suggested that much of the water movement across the property was within the shallow underlying sand and gravel and surface flow was as sheet flow. Therefore, knowing that historically that there was significant groundwater movement within the underlying sands and gravels (+/- 18" below the soil surface) it was decided that field tile would be laid on contour along and within the underlying sand and gravel to discharge the runoff in "reverse French drain" infiltration pipes. Runoff would be collected by connecting to field tiles draining onto the property near the property line and redirecting the flow into the infiltration pipes. The reverse French drains would weep water out over very long interfaces. The locations of the pipe were selected based on the hydric soil limits delineated on the property. The pipes would have relief points to allow surface discharge if the pipe became full to prevent upstream blockages.

Additionally, along extended stretches of pipe where the hydric soil limits elevation moved downward in elevation, internal drop structures/weirs would be installed in the pipe to hold water within each level section. As shown in figure 4, which illustrates a portion of the restoration area, the infiltration pipe installation is quite extensive (several miles) being located above the remnant fen and remnant wet prairie area.

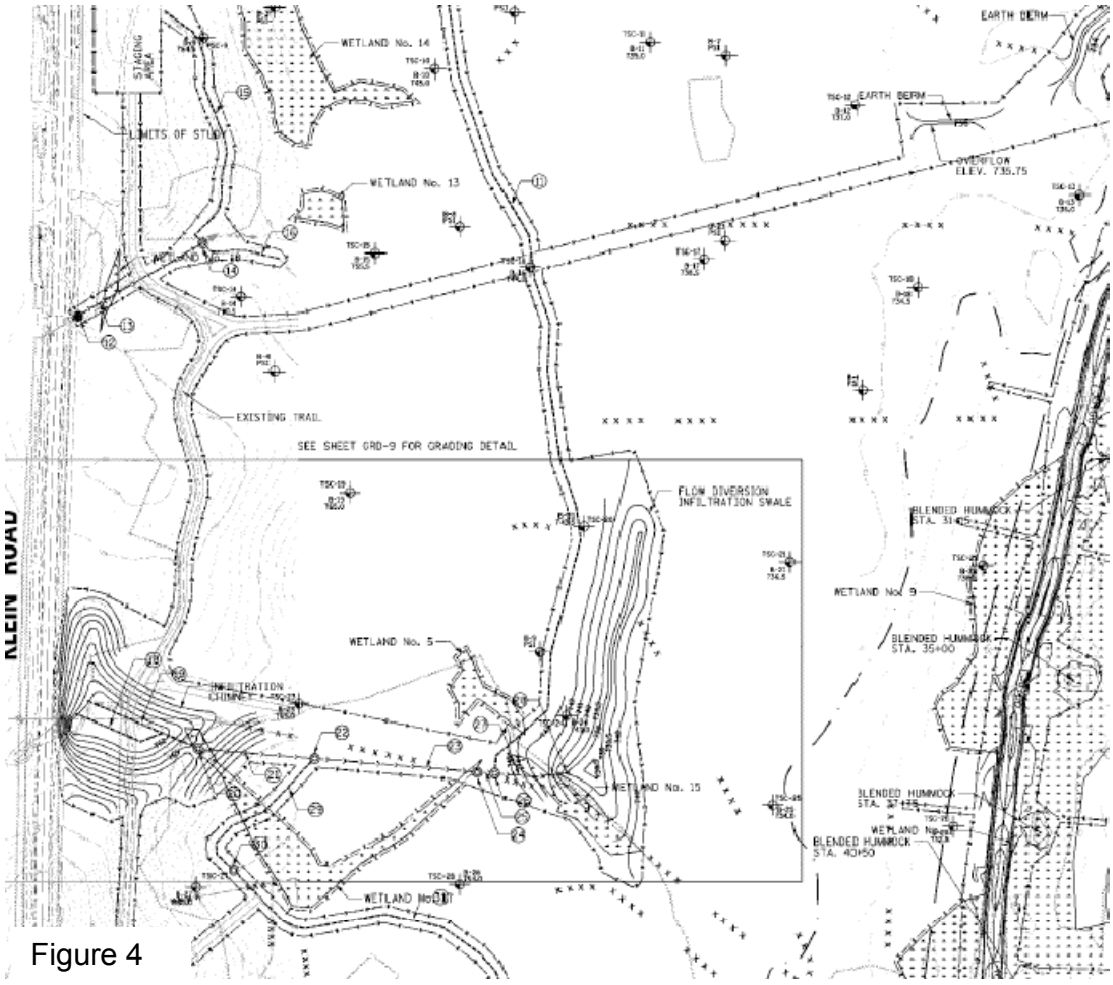

Figure 4

Infiltration Ponds

At two locations along the west side of the preserve, significant off site surface flow discharges onto the property. At both locations, the flow was erosive and carved deep ruts through the remnant fen. In particular, the south drainage was a +/- 10' deep rut through the +/- 10 feet deep hydric soil. This rut acted as a sump draining the surrounding fen soils. At the bottom of the rut groundwater pours into the channel further eroding the bank due to toe failure, slumping and sloughing.

Restoration of the fen would mean that the surface flow would have to be redirected and the ruts back filled. A creative solution was developed. Fifty five soil borings and numerous hand probes were completed throughout the site. It was decided that ponds carefully designed to fit the surrounding topography would be constructed at the point of entry to the property. The bottoms of the ponds would be over excavated down to the underlying sand and gravel. The pond bottoms would then be backed filled with similar sand and gravel to the pond surface, the goal being to infiltrate all surface flow into the underlying sand and gravel.

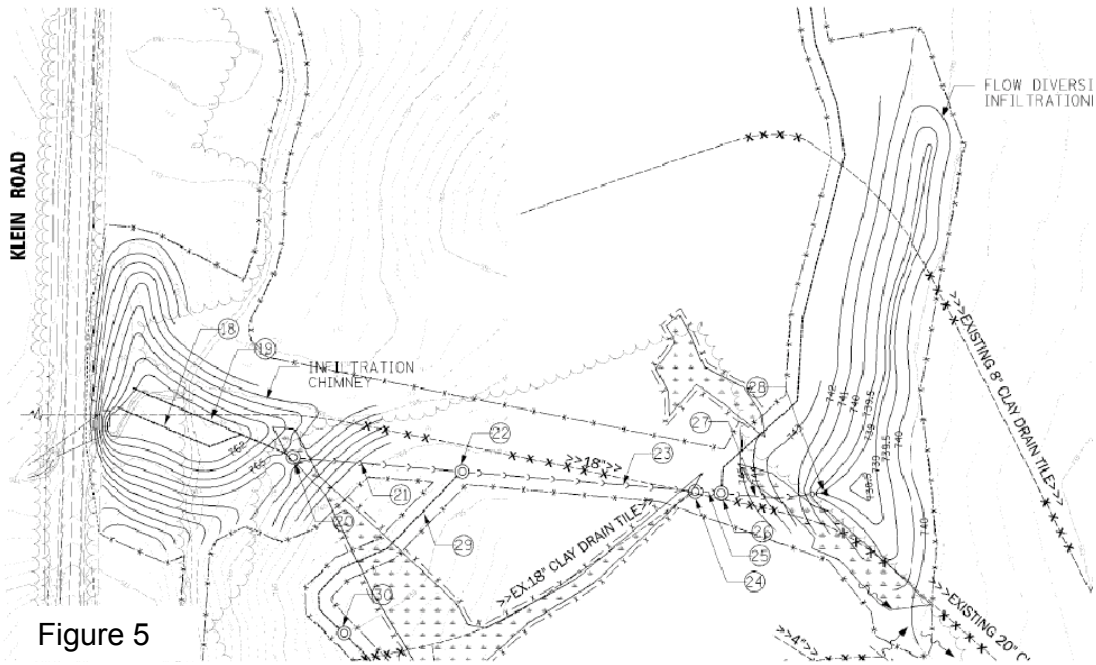

Figure 5

Figure 4.

The ponds were not designed to have much capacity given the need to fit them into the surrounding topography. We calculated that there would be storm events in excess of the capacity of the ponds to infiltrate surface runoff fast enough. Consequently, backup plans were developed. Within the pond bottoms an underdrain system would be installed. A manhole would be installed containing a weir that would over top in the event the hydrostatic pressure of the water within the pond forces the water over the weir. The elevation of the weir was set below the emergency overflow elevation of the ponds.

If water were to pass over the weir, it would enter the infiltration pipes discussed above. But a back up to the infiltration pipes was included. It was possible that the rain event would be so severe as to overwhelm the capacity of both the pond and

infiltration pipes. A second relief pipe would be added that would drain runoff downhill (+/-20' vertically) to a small constructed wetland that would act as a level spreader to gently release runoff into the flood plain and surrounding wetlands at grade.

The by-pass pipe would be installed within the existing ruts and the ruts back filled nearly to original contour. The ponds, if all of the backups failed would discharge overland into newly constructed vegetated swales where the ruts once existed. The goal of all of these systems is to move water downhill in a non-erosive manner while maximizing the rehydration of underlying sands and gravels.

The fen originally formed on the hillside because groundwater discharged onto the surface as a spring causing a hillside wetland to form. Due to the significant modification of the site hydrology from installation of field tiles and drainage ditches, runoff has been by-passing the fen for many years. Rehydration of the underlying sand and gravel should restore the ground water flow and rehydrate the fen allowing the unique fen plant communities to once again flourish.

Wet Prairie and Upland Restoration Activities

The infiltration pipes and ponds will promote the restoration of site hydrology, but vegetation restoration is a major project component. Within the entire project site all non-native and invasive trees and shrubs will be removed; the most abundant species being buckthorn. Supplemental native seed, trees and shrubs will be installed within designated areas throughout the site. A 10 year maintenance and monitoring program will be implemented that includes completion of prescribed burns, herbiciding, reseeding, replanting, monitoring and project compliance reporting.

River Restoration

Prior to settlement, the river was likely a narrow shallow channel that ran through a broad wetland valley that at times may have gone dry. Now the river is channelized, widened and deepened, in an urbanized area, receives waste water treatment plant runoff and has perennial flow. Historically, runoff would over top the shallow channel frequently and flood the lower flood plain, and drain out slowly over a period of days or weeks. Now, because the river has been channelized and deepened, the frequency and duration of overbank flooding is less, altering the historic hydrologic cycle. Additionally, the river channel acts as a sump to the surrounding flood plain because the channel bottom elevation is significantly below the surrounding grade and located within the sand and gravel which underlies much of the site. Groundwater freely discharges into the river.

The river's current condition would be problematic to wetland creation due to the sump condition it causes. Even though field tiles would be disabled, the underlying sands and gravel would continue to drain the area. The solution to this problem was to raise the river bed elevation to eliminate the sump condition, promote river water infiltration into the underlying sands and gravels and promotion of more frequent overbank flooding of the surrounding flood plain by small storms. Raising the riverbed would also flood or block the outlets of any remaining functional field tiles that may have been missed during removal.