Phase II - Northern Service Area Drainage Improvements Stormwater/Groundwater Modeling Summary Report

Village of Kronenwetter
Marathon County, Wisconsin

Project No. 08999006

March 2012

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I. EXECUTIVE SUMMARY

MSA Professional Services (MSA) has completed preparation of baseline groundwater modeling, calibration and analysis for development of the Northern Service Area storm drainage improvement alternatives which will serve Meadowood, Golden Pond Estates, and northern portion of Forest Haven Subdivisions in the Village of Kronenwetter. A number of alternatives have been identified to address high groundwater elevations experienced during the spring thaw season and more significant rain events. The groundwater drawdown impacts of these alternatives have been substantiated through MSA's model development and evaluations.

Groundwater modeling was completed using Groundwater Modeling System (GMS) software, a graphical interface to the groundwater model MODFLOW. MODFLOW is a 3D, cell-centered, finite difference, saturated flow model developed by the United States Geological Survey. The study area is located on the eastern side of Village of Kronenwetter; it is bound by County Road X to the west and north (except in the northeast it also includes the Tower Woods neighborhood), Pleasant Drive to the east, and Wood Road to the south. Additional details on the development of the model are contained in the body of this report and the attached figures in Appendix A.

Two main routing alternatives have been identified in this study: 1) An interior subdivision routing west along Forest Grove and Meadowood from Golden Pond with outlet west of CTH-X into the existing storm sewer system at Bonneydune, and 2) Extension along the south side of CTH-X and Pine Road from Golden Pond to existing storm sewer at Rainbow Drive and Pine Road. Several variations to these two primary alternatives are further investigated in this report. Additional details of each alternative are contained in the body of this report. Routing maps of the considered alternatives and cost estimates are included in Appendix B.

A. Chronology of Activities

Field work (survey) was completed along the interior subdivision route in December prior to model development and the full alternatives analysis. Several reasons drove the decision to initiate field work in December 2011. First, Northern Service Area construction improvements were desired by the Village in early April 2012. This early 2012 construction deadline was due to the severity of the preceding winter flooding and concerns of the recurrence of flooding in the spring of 2012. In order to meet that goal field work had to be completed prior to winter setting in. Second, with the previous investigation work by MTS and pumping in 2011 the Village and MSA were relatively certain that the subdivision routing was a viable long term improvement route. Based on these considerations, in December, the decision was made to proceed with the interior subdivision field work.

Upon completion of the initial field work and model development in January, MSA met with the Village to discuss routing alternatives for the Northern Service District drain improvements. Design limitation due to existing utility conflicts along the interior subdivision route limited the depth at which connection to Golden Pond could be made (approximately 1188.0’). Concern was also raised as to the capacity of the existing downstream drainage system west of Bonneydune and the desire to avoid easement acquisition along the route. For these reasons the routing evaluation was expanded and the CTH-X alternative was developed.

Through iterations of our completed groundwater model for these alternatives, MSA has projected the most significant groundwater reduction impacts to the area through the lowering of the Golden Pond water elevation. Three different elevation stages have been considered; 1187, 1188 and 1189. Currently (3/13/2012), the elevation of Golden Pond is 1189.47’.

On February 20, MSA presented both the interior subdivision and CTH-X routing alternatives, groundwater model evaluation results and preliminary cost estimates to the Village’s Property and Infrastructure Committee (PIC). Based on this presentation and discussion the PIC committee recommended the CTH-X routing option. On February 27, this recommendation was brought to the Village Board. The Village Board requested that MSA complete the CTH-X route survey, verify the viability of this option and also to perform additional modeling evaluations prior to acting on the PIC Committee’s recommendation.

Completion of the additional requested fieldwork has shown the CTH-X route to Rainbow Drive as feasible from a construction point of view. Additional modeling of the underdrain “fingers” show a positive impact to groundwater drawdown. Also, additional modeling of an indirect underdrain connection to Golden Pond along Paniolo Drive in lieu of direct connection was performed. The results indicated that adequate groundwater drainage and ultimately pond elevation control could not be accomplished with this option. These results are described in more detail in the body of the following report.

The Northern Service District drain improvement alternatives are summarized in the following table.

Table 1 - Alternative Summary

Alternative	Description
Alternative #1	Perforated underdrain installed along Forest Grove Ave. to Golden Pond with no direct pond outlet.
Alternative #2	Non-perforated storm sewer installed along Forest Grove Ave. to Golden Pond with direct pond outlet.
Alternative #3	Non-perforated storm sewer installed along CTH-X/Pine Road to Golden Pond with direct pond outlet.
Alternative #4	Non-perforated storm sewer installed along CTH-X/Pine Road to Golden Pond with direct pond outlet. Perforated underdrain installed south along CTH 'X' and Meadow Drive.
Alternative #5	Non-perforated storm sewer installed along CTH-X/Pine Road to Paniolo Road. Perforated underdrain installed south along Paniolo Road adjacent to Golden Pond.

II. GROUNDWATER MODEL DEVELOPMENT

The evaluation of alternatives for lowering groundwater levels within the Village of Kronenwetter for the portions of the Village east of CTH 'X' was conducted using a model of the surface groundwater aquifer. The model used for this project was Aquaveo GMS, a GUI-interface for the MODFLOW model developed by the USGS.

The purpose of the groundwater modeling was to develop a transient model calibrated to match observed water levels in valve boxes located in 2011, and then to use the calibrated model to predict the effectiveness of alternative management practices for lowering the maximum water table elevation during wet periods, in residential areas prone to basement flooding.

A. Study Area Description

The limits of the study area are shown on Figure 1. The study area extends west to the Wisconsin River, from below the Rothschild Dam in the north to above the Mosinee Dam in the south. The model is bounded to the north, south and east by the Marathon formation. Bull

Junior Creek also lies along the south boundary while extensive wetlands also lie to the north and east. The west boundary is the Wisconsin River.

The study area overlies an unconfined aquifer composed of highly permeably sandy gravel and gravelly sand deposited by meltwater streams during the last part of the Wisconsin Glaciation. Regionally, the aquifer is bounded by bounded by hilly crystalline bedrock and irregularly distributed clayey deposits mapped as belonging to the Marathon Formation (Kendy and Bradbury, 1988; Attig and Muldoon, 1989). The Marathon formation is comprised of gravelly, sandy, clayey silt derived from bedrock and glacial sediment (Attig and Muldoon, 1989). The aquifer material is highly heterogeneous with published values of hydraulic conductivity ranging from slightly less than 1 foot per day to more than 80 feet per day (Kendy and Bradbury 1988). The hydraulic conductivity of the Marathon Formation is reported to be in the range of 0.02 feet/day (Attig and Muldoon, 1989) - two to three orders of magnitude less than that of the aquifer that it contains.

B. Steady State Modeling

Steady state flow occurs when the magnitude and direction of flow is constant with time throughout the study area. Construction of a steady state model is the first step in the development of a groundwater model as it generally includes establishment and testing of model parameters that do not change during the model simulation. By first identifying and establishing the values for parameters which do not change, it allows future model development activities to more effectively and accurately focus on parameters which may change over time.

Boundary Conditions. Because the difference in hydraulic conductivity between the aquifer and the surrounding material is greater than two orders of magnitude, the Marathon formation (north, east, and south boundaries) was modeled as no-flow boundary. The Wisconsin River (west boundary) was modeled as a constant head boundary, with the upstream elevation taken from a USGS gauging station located downstream of the Rothschild Dam, and the downstream elevation taken as the spillway elevation of the Mosinee Dam.

Other surface water bodies internal to the model were also modeled as constant head boundary conditions, including Bull Junior Creek, Cedar Creek, and various wetlands. Water level elevations for these were primarily obtained from USGS mapping, except for Bull Junior Creek, for which water level elevations were obtained from survey data (within the study area) and FEMA floodplain mapping (downstream of the study area).

The boundary conditions for the transient model were developed and tested by creating a steady state regional model (the limits of the regional model are shown in bold black on Figure 1). Once the regional model was operating satisfactorily, the model was scaled down to a local model area (shown in pink in Figure 1) so that additional detail could be added and transient conditions for simulation of groundwater recharge and extraction could be simulated. The regional model area limits are defined by the 1170 groundwater elevation contour on the west and the 1205.2 groundwater contour elevation on the east. The regional model area was truncated to the limits of the local model area by assigning constant head boundary conditions at the locations of these respective contour lines.

Hydraulic Conductivities. Hydraulic conductivity is a property soil that describes how quickly water can move through pore spaces within the soil. For purposes of this model study, establishment of soil hydraulic conductivity was the principal model calibration effort. For all areas mapped as meltwater stream sediment or non-glacial stream sediment an average hydraulic conductivity of 50 feet/day was assigned. This value was found to best represent average aquifer conditions in a 1994 study of the area immediately west of the current study area (SEH, 1994). Areas mapped as peat and muck were assigned a hydraulic conductivity of 5 feet/day and internal “islands” of clay or bedrock were assigned a hydraulic conductivity of 1 foot per day and 0 feet per day, respectively.

Groundwater Recharge. Groundwater recharge is a hydrologic process where water moves downward from surface water to the groundwater aquifer. For steady state simulations a constant groundwater recharge rate of 0.0013 feet/day was assigned to the model. This value represents the average water budget in a typical year for this region.

C. Transient Modeling

Transient flow occurs when the magnitude and direction of the flow changes with time. In the case of groundwater modeling as applied to Kronenwetter, the principal changes of concern are groundwater recharge due to rainfall, groundwater extractions due to pumping, and the differences in groundwater elevations throughout the model that result from additional and removal of water from the system at different times and for different durations.

Transient modeling was completed for the duration spanning April 1, 2010 to August 10, 2011. This time span included various ‘stress periods’ where groundwater recharge input varied. The first stress period simulated a 1-year steady state condition which was necessary to generate a reasonable starting condition for the April 1, 2011 to August 10, 2011 simulation period. The remaining stress periods included in the model for this time span simulated predicted groundwater recharge events based on regional rainfall events or the times between groundwater recharge events. Groundwater recharge events were estimated using a hydrologic budgeting spreadsheet tool. Recharge was predicted to occur on days when the cumulative depth of water in a shallow storage layer exceeded the estimated maximum root zone storage of 1.4 inches. Over the transient period of record modeled there were a total of 9 recharge events totaling 3.52 inches of recharge, out of a total of 15.79

inches of precipitation. Chart 1 on the following page compares rainfall data obtained from the Wausau airport to estimated groundwater recharge data.

For the model run simulating the actual conditions experienced in the summer of 2011, the elevation of Golden Pond was modeled as an internal, transient, general head boundary condition. This was necessary to simulate the effects that pumping water from the pond had on water levels in the pond and subsequently on groundwater levels within the surrounding aquifer. The daily water level elevation in the pond was calculated using a hydrologic budget spreadsheet that accounted for rainfall, evaporation and pumping records obtained from Village staff. Chart 2 on the following page compares observed elevations in Golden Pond to simulated elevations used for model boundary conditions.

Chart 1
Rainfall vs. Groundwater Recharge

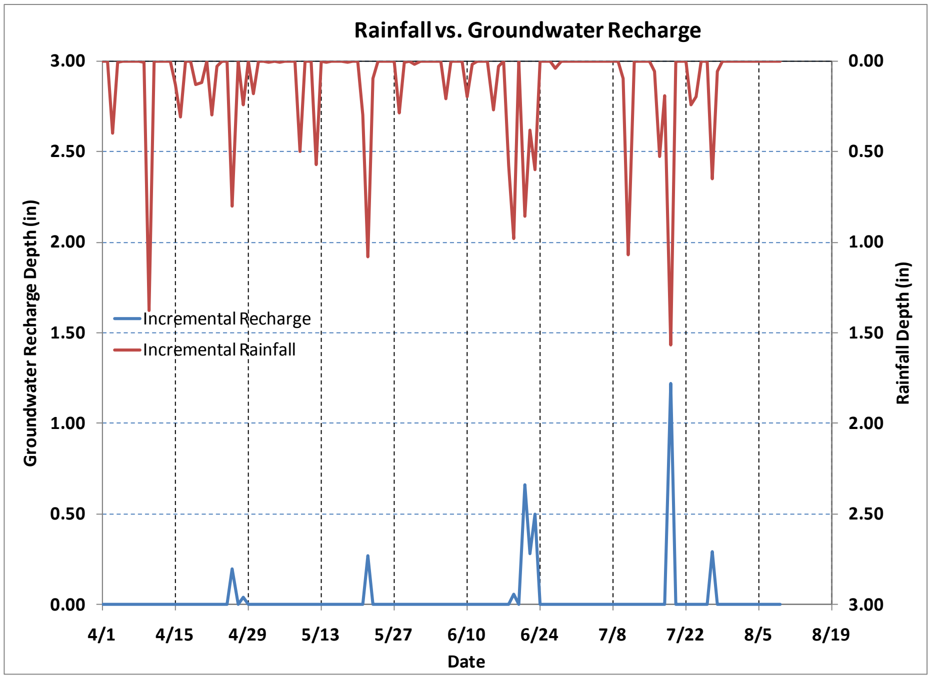
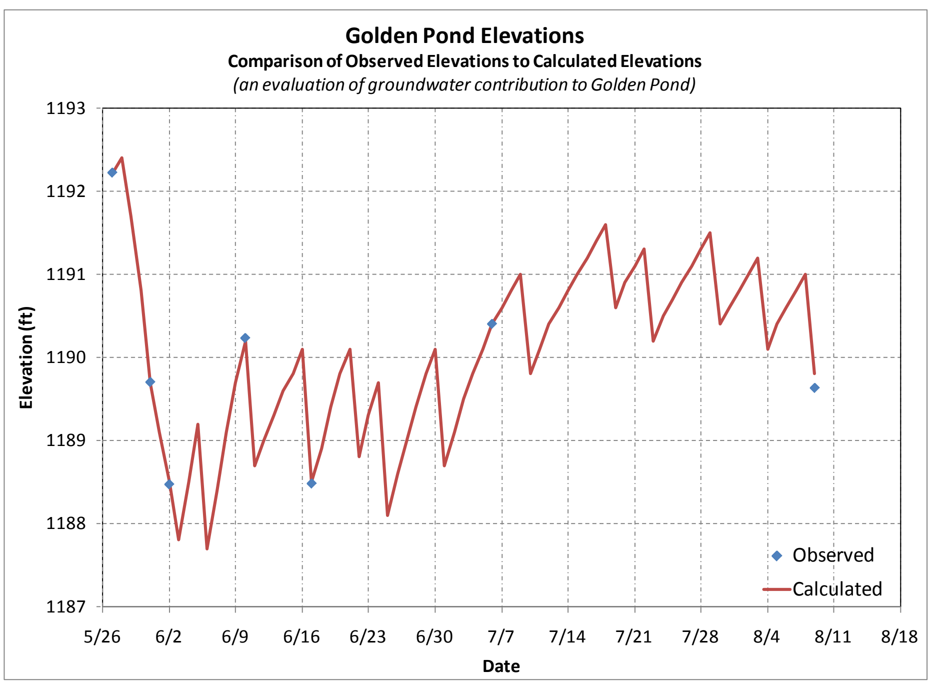


Chart 2
2011 Golden Pond Elevations



D. Model Calibration

The transient model was calibrated by adjusting hydraulic conductivity values for soils within the study area until model output adequately matched observed water level elevations on seven different dates and in 49 valve boxes distributed throughout the study area. Particular emphasis was placed on the three measurement dates with the most observation points, and for which water table contours had been mapped, May 27, July 5, and August 9 (MTS, 2011). In order to better match observed groundwater elevations, hydraulic conductivity values were reduced from the average 50 ft/day determined by the 1994 SEH study to the values shown in Figure 2. Adjustments made to hydraulic conductivity values are consistent with field reports from local drillers of a "bedrock ledge" that runs along the western edge of the study area, and areas of clayey materials in the vicinity of the study area.

The final version of the calibrated model results, as shown in Figures 3, 4 and 5, produced water table contours similar in shape to observed conditions. Within the portion of the study area of most interest (near Golden Pond) predicted elevations were generally within one feet of observed conditions on May 27 and a within half a foot or less on July 5 and August 9. In general, predicted elevations become closer to observed elevations as the simulation progresses; this is speculated to be the result of the system adjusting progressively further from "average steady-state" conditions as the period of record proceeds.

E. Evaluation of Alternatives to Control Groundwater Elevations

Once the model was determined to be satisfactorily calibrated, it was used to predict the effects of proposed management solutions for lowering water table in the vicinity of Golden Pond. The first step in this evaluation was to determine the estimated peak groundwater levels that would have been expected to occur during summer 2011 had the Village not pumped water from Golden Pond. The resulting envelope of 'worst-case-scenario' groundwater elevations as shown on Figure 6 was used as the baseline comparison point for evaluating the effects of the various alternatives.

There were five alternatives evaluated in this study as previously described and shown in Table 1. They include:

Alternative 1 – Drain tile running west from CTH 'X' along Forest Grove Ave. to Paniolo Rd.

Alternative 2 - A solid pipe following the alignment of Alternative 1 providing a surface outlet to Golden Pond.

Alternative 3 – A solid pipe running along Pine Road/CTH 'X' from Rainbow Drive to a surface outlet to Golden Pond

Note that there are three representations of alternatives 2 and 3, one each at pond outlet elevation 1187, 1188, and 1189.

Alternative 4 – All elements of Alternative 3 plus drains tile running south along CTH X and south along Meadow Drive. Note that the Golden Pond surface outlet for Alternative 4 is at elevation 1187.

Alternative 5 – is a modified version of alternative 3 but with a drain tile along Paniolo Road instead of a surface outlet to Golden Pond.

Alternatives involving drain tiles were modeled using the MODFLOW "drain" package. "Drain" cells remove water from the aquifer as long as the water table is above the elevation of the drain and have no effect when the water table falls below the elevation of the drain. Cells located along the alignment of the proposed pipe were modeled as a drain, and assigned an elevation equal to the proposed invert of the drain tile at the location of the cell.

The rate that water is removed from the aquifer by drain cells is proportional to the difference in elevation between the water table and the drain, and a constant of proportionality referred to as "conductance". The appropriate conductance value for the proposed drain was arrived at by an iterative process, wherein the conductance value was adjusted so that maximum discharge rate into the drain tile(s) was equal to the tile's full-flow hydraulic capacity as determined by Manning's equation, and the predicted water table elevation in the drain cells was equal to the predicted flow line in the pipe for the given discharge rate..

The effects of the various surface outlets to Golden Pond were simulated by modeling Golden Pond as a constant head boundary under each of the different proposed pond outlet elevations (1189, 1188, and 1187 feet).

F. Model Results

Model results are shown in figures 7 through 24 and are presented in sets of three. The first figure presents predicted groundwater elevations as viewed from a regional perspective. Groundwater contours shown on these maps at presented at one-foot intervals. The second figure presents the same information as the first, just at a smaller 'neighborhood' scale. Also, groundwater contours are shown at tenth-of-a-foot increments for greater precision and for comparison to known basement elevations. The final figure in each set is a color representation of the depth that groundwater would be lowered by the respective alternative in comparison to baseline conditions represented in Figure 6. Specifically, the data represented in the third figure of each set is the result of the subtraction of groundwater elevations shown in the first figure of the set from the groundwater elevations shown in Figure 6.

Also note, modeling for this study was conducted at a very fine scale as far as groundwater studies go. The size of each cell within the model was only 104 feet in each dimension. However, regardless of this comparatively small model cell size the precise location of each model cell did not exactly align with the location of existing or proposed physical structures. As such representation of the effects of these structures on the groundwater maps presented in this report may appear slightly offset from where the exact benefit might be observed in reality.

III. NORTHERN SERVICE AREA – PHASE II DRAIN IMPROVEMENT ALTERNATIVES

At the PIC meeting on February 20, 2012, MSA presented details of the model development and improvement alternatives for Phase II construction. The PIC recommended improvement (hereinafter identified as Alternative #4) consists of the installation of an 18" diameter "non-perforated" storm sewer from an existing 18" storm sewer on the south side of CTH-X at Rainbow Drive, extending east along the south side of CTH-X to Paniola Drive then south with direct connection to Golden Pond. 12" diameter perforated under drain "fingers" will extend south along CTH-X and Meadow Drive to provide additional groundwater drainage.

For background purposes, this option was presented to the PIC committee as a base option of connecting to existing storm sewer at Bonneydune Drive with one additive alternate for extending the proposed storm sewer west to Rainbow Drive and another additive alternate for extending under drain 'fingers' south along Meadow Drive and along CTH-X. It was the PIC committee's recommendation to incorporate the base option and both additive alternates into the single recommended project.

Proposed work to be included with the selected improvement will include extending 18" non-perforated storm sewer east along Pine Road from the intersection of Rainbow Drive and Pine Road to Golden Pond for the purpose of lowering/controlling the Golden Pond surface water level and adjacent groundwater levels. The proposed storm sewer will be installed primarily through open cut construction due to the minimal slope available along the proposed route (approximately 0.23%). Directional drilling is proposed for the CTH-X intersection crossing to avoid high restoration costs of the intersection and impact to traffic. With a pipe slope of 0.23% from the existing structure's invert elevation, Golden Pond could be lowered to an elevation of 1187.00. Work also includes the installation of a 12" perforated underdrain 'finger' south along CTH X and east throught a private easement to Meadowood Drive as well as the installation of a 12" perforated underdrain 'finger' south along Meadow Drive to the intersection of Meadow Drive and Meadowood Drive. Both 'fingers' will be installed utilizing open-cut construction so that a wrapped stone trench section can be installed to promote groundwater drainage.

Manholes will be installed with proposed storm sewer and underdrain for access and cleaning purposes. A storm water control structure will be installed near Golden Pond to control both the pond surface water (groundwater) level as well as the amount of drainage discharged downstream to the existing storm sewer system.

MSA recently completed survey and basemap work along CTH-X/Pine Road from Paniolo Road to Rainbow Drive to verify the validity of the CTH-X storm sewer alternative with either direct connection to Golden Pond or under drain along Paniola. Based on our evaluation of the completed survey and basemap work, no conflicts exist between the proposed 18-inch storm sewer and existing sanitary sewer due to the significant depth of the sanitary sewer in this area. The storm sewer will cross existing sanitary sewer mains at Morningside Drive, Marbella Drive, CTH ‘X,’ and Meadow Drive. There is the potential for conflict with a small number of sanitary sewer laterals due to the unknown profiles of the existing laterals. The sewer lateral elevations will be confirmed in the field during construction and adjusted as necessary for installation of the storm sewer. Water main offsets (lowering of the existing water main) may also be necessary at two intersections; Pine Road/Meadow Drive and Pine Road/Paniolo Road. MSA obtained approximate depths of the existing water main along Pine Road from existing valve boxes. It is likely that water main offsets will be required at these two intersections to accommodate the proposed storm sewer and estimated costs for this are included. Existing storm sewer along the south side of Pine Road will need to be removed from Rainbow Drive to Marbella Drive prior to the installation of new 18” storm sewer.

An underground electric line runs along the south side of Pine Road, adjacent to the proposed storm sewer from Morningside Drive to Bonneydune Drive. An overhead electric line runs along the south side of Pine Road, adjacent to the proposed storm sewer from Bonneydune Drive to Paniolo Road. Other private utilities adjacent to the proposed storm sewer on the south side of Pine Road include a buried telephone line at varying locations, another buried electric line from CTH ‘X’ to Paniolo Road, and a buried gas line from CTH ‘X’ to Paniolo Road. These utilities are not expected to be in direct conflict with the proposed storm sewer.

Based upon our evaluation of this route we have identified the following list of pro’s and con’s to the CTH-X/Pine Road Alternative (Alternative #4):

<u>Pro’s</u>

- Allows the maximum potential for drop in pond elevation. Approximately 1-2’ lower than the “base CTH-X option” or other considered options.
- Bypasses existing 12” storm sewer west of CTH-X and south of Pine Road and concerns over capacity of existing sewers.
- Minimizes construction impacts compared to other considered options.

- Deeper “finger underdrains” on CTH-X and Meadow Road allow for future expansion of under drain into Meadowoods and Golden Pond Estates, if needed.
- Minimizes the acquisition of easements for construction.

Con’s

- Extension to existing 18” to provide added depth is more costly option compared to “base option”.
- Unknown sanitary lateral crossing elevations and possible water main crossing relocation.

Appendix B includes the proposed routing map and cost estimate for the PIC recommended option (Alternative #4).

IV. OTHER CONSIDERED OPTIONS

Four additional alternatives were considered during the evaluation process. These other alternatives are more fully described in the following summaries:

A. Alternative 1

Consisted of the installation of an 18” diameter “non-perforated” storm sewer from Bonneydune Drive (approximately 300’ south of Pine Road) through proposed private utility easements utilizing horizontal directional drilling to CTH X. From that point a perforated under drain in a fabric lined stone trench using open cut construction along the existing easement between CTH-X and Meadowood Drive and then along Meadowood, Meadow, Forest Grove and Paniola adjacent to Golden Pond. No direct connection to Golden Pond was proposed for this option. Storm laterals were proposed to property lines of adjacent lots to allow homeowners to connect their sump pump discharge lines to the proposed storm sewer. A storm water control structure was proposed at the outlet in Bonneydune Drive. See Appendix B for Alternative 1 routing map and cost estimate.

B. Alternative 2

Consisted of the installation of an 18” diameter “non-perforated” storm sewer from Bonneydune Drive (approximately 300’ south of Pine Road) through proposed private utility easements utilizing horizontal directional drilling to CTH X. From that point the non-perforated storm sewer would be installed utilizing open-cut construction along the existing easement between CTH-X and Meadowood Drive and then along Meadowood Drive, Meadow Drive, Forest Grove Avenue and Paniola Road to provide a surface water outlet at Golden Pond. Storm laterals were proposed to property lines of adjacent lots to allow homeowners to connect their sump pump discharge lines to the proposed storm sewer. A storm water control structure was proposed near Golden Pond to control both the pond surface water (groundwater) level as well as the amount of drainage discharged downstream to proposed storm sewer. A storm water control structure was also proposed at Bonneydune

Drive to control the amount of storm water discharged downstream to existing storm sewer. See Appendix B for Alternative 2 routing map and cost estimate.

C. Alternative 3

Compared closely to the PIC recommended Alternative 4, with the only difference being the exclusion of the installation of a 12” perforated underdrain ‘finger’ south along CTH X and east through a private easement to Meadowood Drive as well as the exclusion of the installation of a 12” perforated underdrain ‘finger’ south along Meadow Drive to the intersection of Meadow Drive and Meadowood Drive. Alternative 3 consisted of extending 18” non-perforated storm sewer east along Pine Road from the intersection of Rainbow Drive and Pine Road to Golden Pond (with surface water outlet) for the purpose of lowering/controlling the Golden Pond surface water level and adjacent groundwater levels. The proposed storm sewer was proposed to be installed primarily through open cut construction due to the minimal slope available along the proposed route (approximately 0.23%). Directional drilling was proposed for the CTH-X intersection crossing to avoid high restoration costs of the intersection and impact to traffic. Manholes were proposed with storm sewer for access and cleaning purposes. A storm water control structure was proposed near Golden Pond to control both the pond surface water (groundwater) level as well as the amount of drainage discharged downstream to the existing storm sewer system. See Appendix B for Alternative 3 routing map and cost estimate.

D. Alternative 5

Also compared closely to the PIC recommended Alternative 4. Alternative 5 also consisted of the extension of 18” non-perforated storm sewer east along Pine Road from the intersection of Rainbow Drive and Pine Road to Golden Pond. This alternative did not include a direct storm sewer outlet connection to Golden Pond. Alternative 5 proposed the installation of perforated underdrain (with a wrapped stone trench) adjacent to the pond in lieu of the direct storm sewer outlet connection. This alternative also differed from the PIC recommended alternative in that no perforated underdrain ‘finger’ was proposed south along CTH X and east through a private easement to Meadowood Drive nor south along Meadow Drive to the intersection of Meadow Drive and Meadowood Drive. Note that the native soils in the area surrounding Golden Pond were a limiting factor in effectively draining groundwater from Golden Pond into an underdrain system that would be installed along Paniolo Road. Groundwater model results for this alternative show the limited groundwater benefit when compared to model results for alternatives that propose a direct connection to Golden Pond. See Appendix B for Alternative 5 routing map and cost estimate.

V. REFERENCES

Attig, John W. and Muldoon, Maureen A., Pleistocene geology of Marathon County, Wisconsin, Volume 65 of Information circular, Wisconsin Geological and Natural History Survey, 1989.

Kendy, Eloise; Bradbury, Kenneth R. Hydrogeology of the Wisconsin River Valley in Marathon County, Wisconsin (1988)

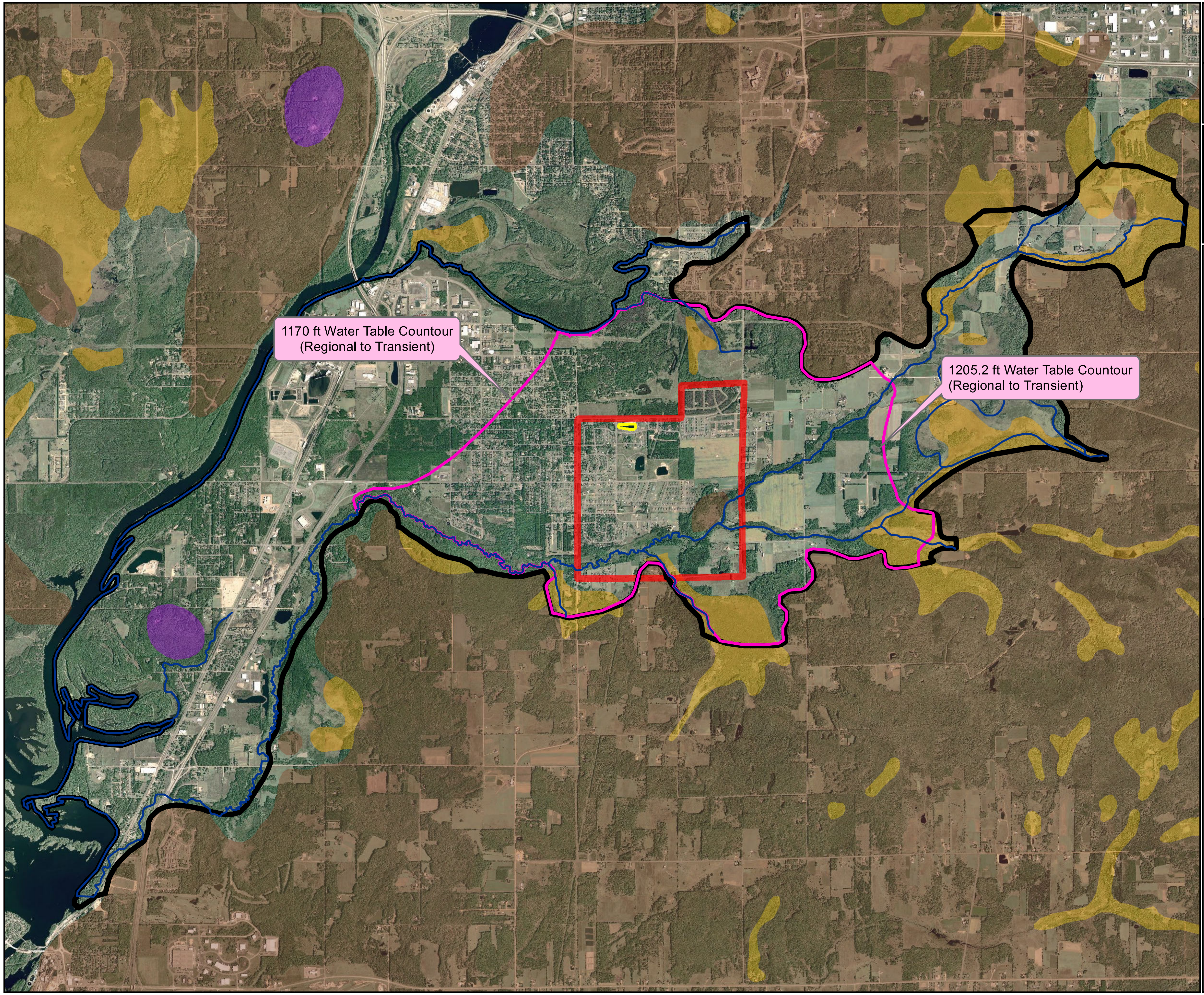
APPENDIX A

Groundwater Modeling Figures

Groundwater Modeling Study Areas

Groundwater Study
Village of Kronenwetter
Marathon County, WI

Figure 1. Regional and Local Model Area



Legend

- Regional (Steady-State) Model Area
- Local (Transient) Model Area
- Study Area Limits
- GoldenPond
- Waterways (Constant Head)

Pleistocene Geology

- Marathon Formation
- Peat and Muck
- Pre-Cambrian Bedrock

Feet
0 4,000 8,000

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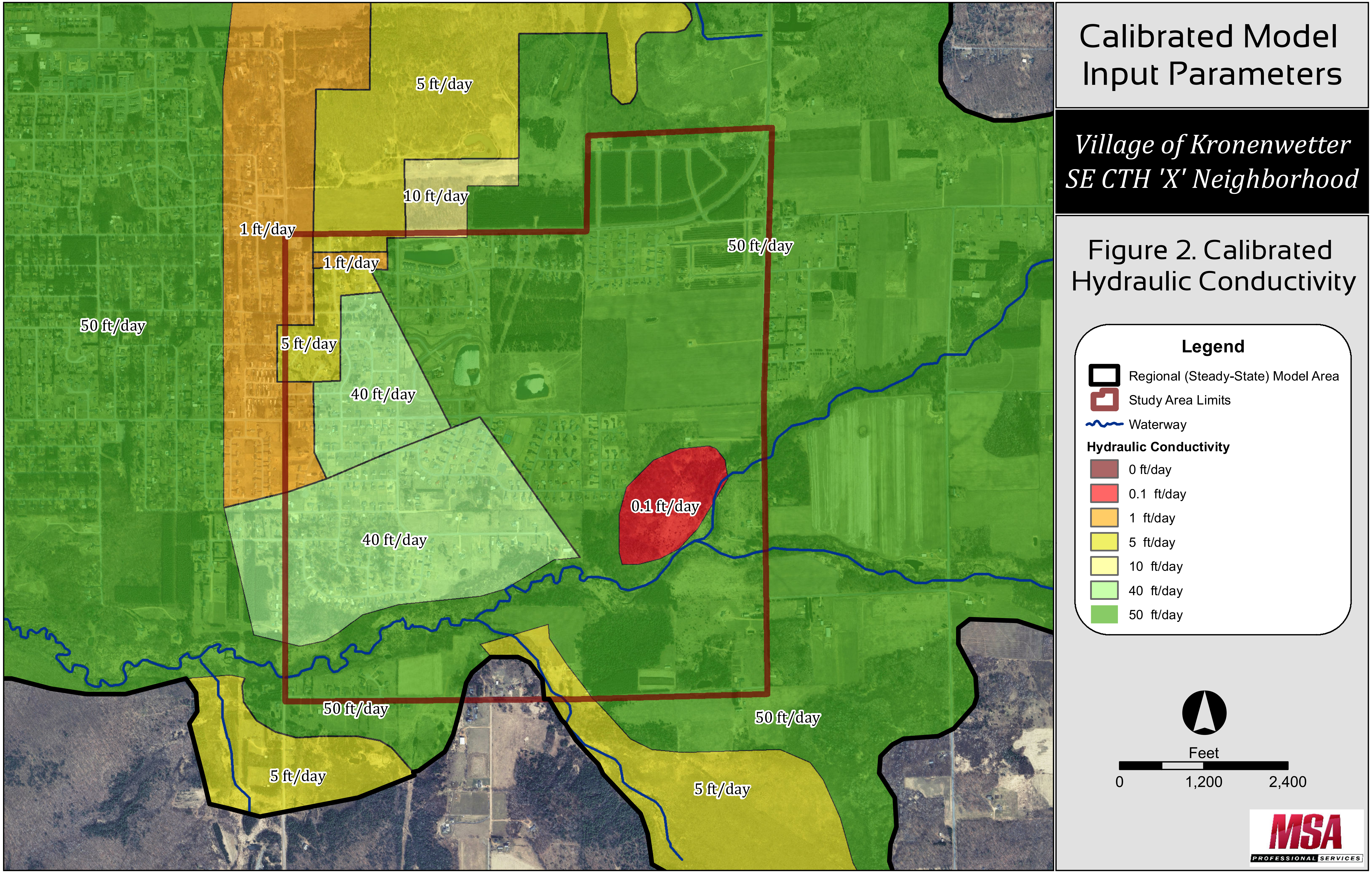
Calibrated Model Input Parameters

Village of Kronenwetter SE CTH 'X' Neighborhood

Figure 2. Calibrated Hydraulic Conductivity



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Maximum Estimated Groundwater During Summer 2011
Calibrated Model vs Measured Ground Water Elevation
May 27, 2011

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-3

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Maximum Estimated Groundwater During Summer 2011
Calibrated Model Results vs Measured Groundwater Elevations
August 9, 2011

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

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SHEET FIG-5

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Maximum Estimated Groundwater During Summer 2011
Calibrated Model Results vs Measured Groundwater Elevations
July 5, 2011

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

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Maximum Estimated Groundwater During Summer 2011

If No Pumping from Golden Pond

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-6

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Maximum Estimated Groundwater During Summer 2011
Study Area View
Alternative 1

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-7

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 1_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Web Address: www.msa-ps.com

Maximum Estimated Groundwater During Summer 2011
Neighborhood View
Alternative 1

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-8

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Baseline_MAX & Alternative 1_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater Lowering During Summer 2011
Alternative 1

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-9

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 2 & 3, 1187_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
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Maximum Estimated Groundwater During Summer 2011
Study Area View
Alternatives 2 & 3, Pond Outlet at Elevation 1187

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006
SHEET FIG-10

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
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Maximum Estimated Groundwater During Summer 2011
Neighborhood View
Alternatives 2 & 3, Pond Outlet at Elevation 1187

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006
SHEET
FIG-11

File Name: P:\8900s\8990s\08999\08999006\CADD\Construction Documents\Plan - Baseline_MAX & Alternative 2 & 3, 1187_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater Lowering During Summer 2011
Alternatives 2 & 3, Pond Outlet at Elevation 1187

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006
SHEET FIG-12

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 2 & 3, 1188_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater During Summer 2011
Study Area View
Alternatives 2 & 3, Pond Outlet at Elevation 1188

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-13

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 2 & 3, 1188_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
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Maximum Estimated Groundwater During Summer 2011FIGF
Neighborhood View
Alternatives 2 & 3, Pond Outlet at Elevation 1188

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006
SHEET
FIG-14

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater Lowering During Summer 2011
Alternatives 2 & 3, Pond Outlet at Elevation 1188

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006
SHEET FIG-15

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 2 & 3, 1189_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater During Summer 2011
Study Area View
Alternatives 2 & 3, Pond Outlet at Elevation 1189

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-16

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 2 & 3, 1189_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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PLOT DATE:					

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Maximum Estimated Groundwater During Summer 2011
Neighborhood View
Alternatives 2 & 3, Pond Outlet at Elevation 1189

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-17

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Baseline_MAX & Alternative 2 & 3_1189_MAX.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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PLOT DATE:					

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Maximum Estimated Groundwater Lowering During Summer 2011
Alternatives 2 & 3, Pond Outlet at Elevation 1189

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-18

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 4.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
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Maximum Estimated Groundwater During Summer 2011
Study Area View
Alternative 4, Pond Outlet at Elevation 1187

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-19

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 4.dwg

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Maximum Estimated Groundwater During Summer 2011
Neighborhood View
Alternative 4, Pond Outlet at Elevation 1187

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-20

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
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Maximum Estimated Groundwater Lowering During Summer 2011
Alternative 4, Pond Outlet as Elevation 1187

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-21

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 5.dwg

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Maximum Estimated Groundwater During Summer 2011
Study Area View
Alternative 5

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-22

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Alternative 5.dwg

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater During Summer 2011
Neighborhood View
Alternative 5

Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO. 08999006

SHEET FIG-23

File Name: P:\8900s\8990s\8999\08999006\CADD\Construction Documents\Plan - Baseline_MAX & Alternative 5.dwg

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PROJECT DATE: 02/2012	DRAWN BY: MN				
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Maximum Estimated Groundwater Lowering During Summer 2011
Baseline_MAX & Alternative 5

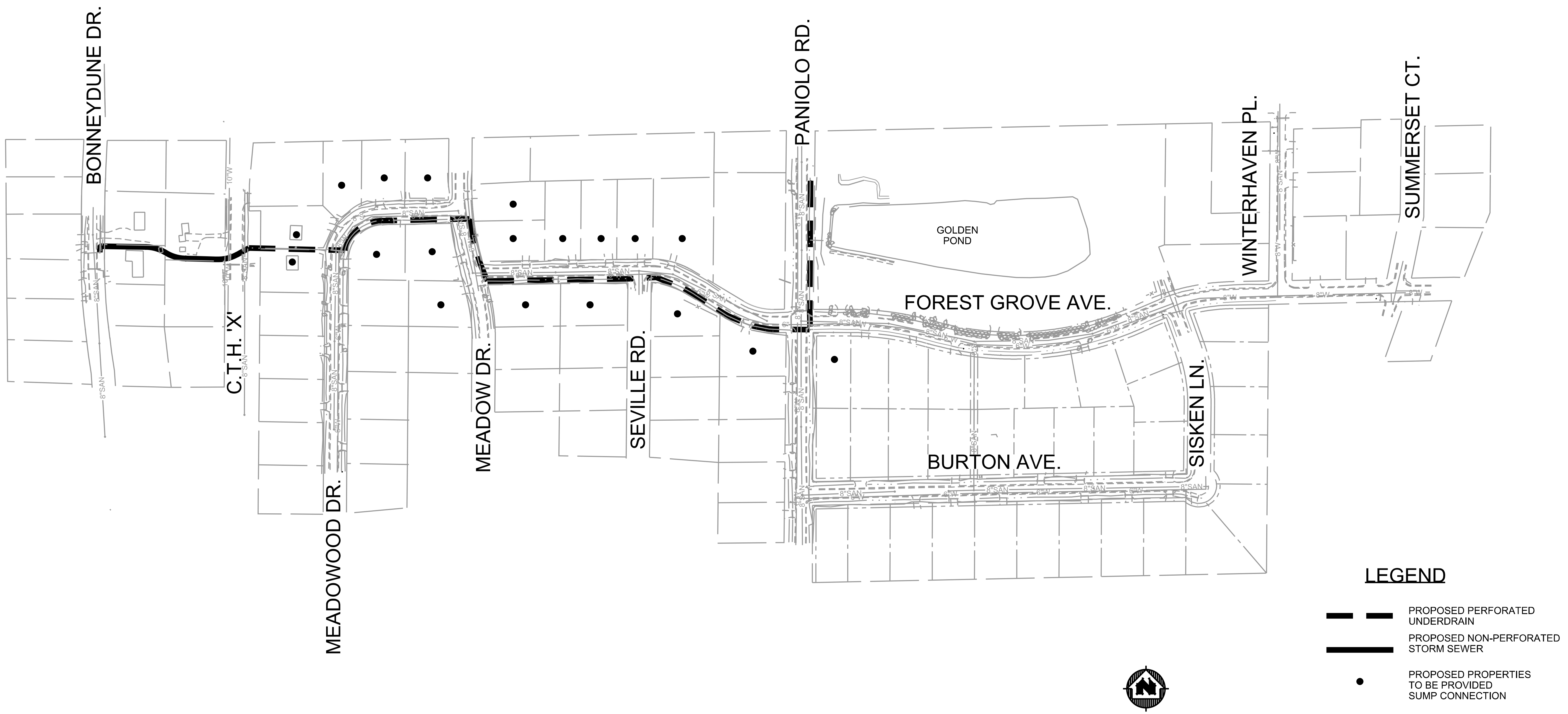
Groundwater Study
Village of Kronenwetter
Marathon County, Wisconsin

FILE NO.
08999006

SHEET
FIG-24

APPENDIX B

Alternative Maps & Cost Estimates



PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: $DATE$	DRAWN BY: AP				
CHECKED BY: ND					
PLOT DATE:					

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715-384-2133 1-877-204-0572 Fax: 715-384-9787
Web Address: www.msa-ps.com

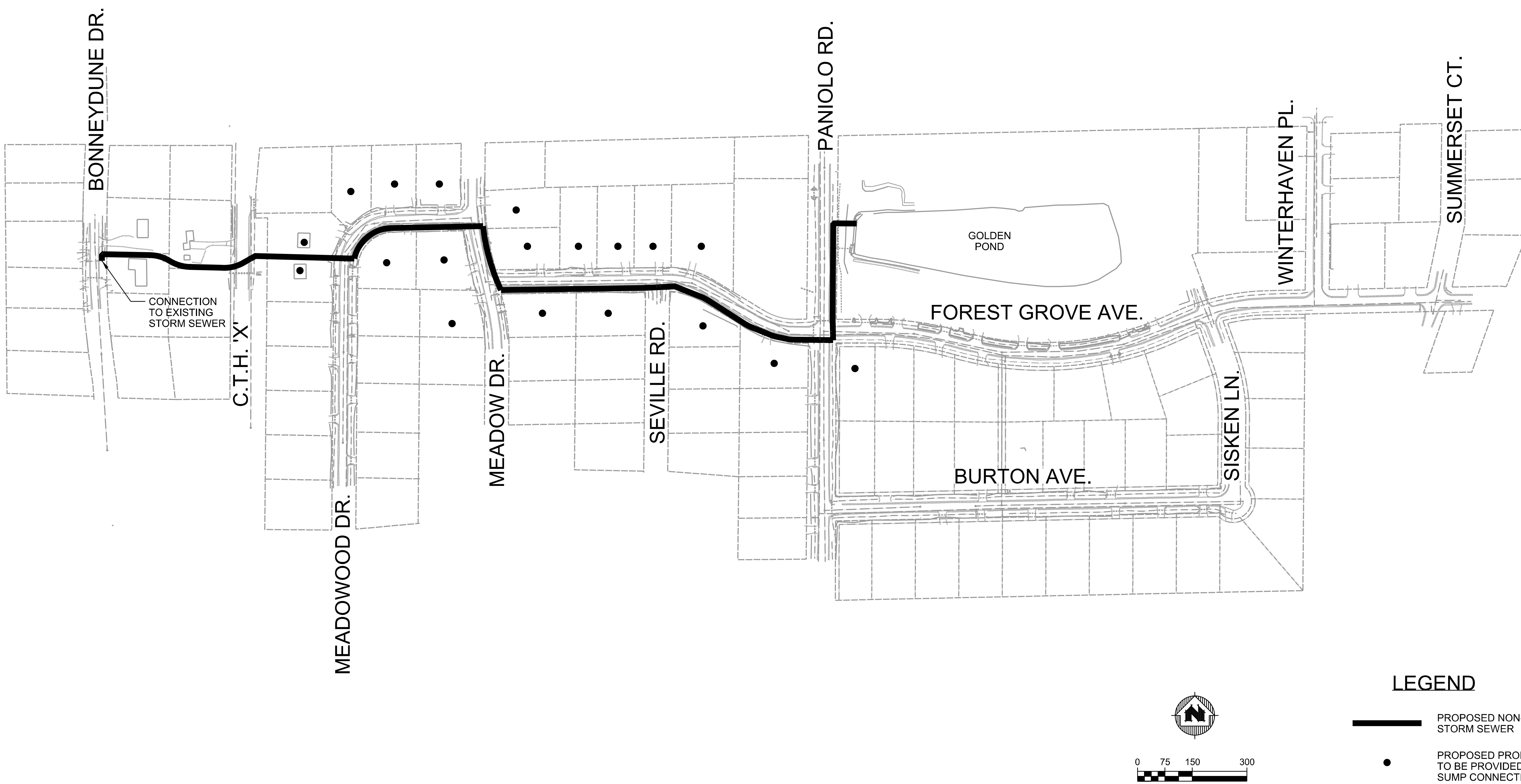
ALTERNATIVE 1

PHASE II DRAINAGE IMPROVEMENTS
VILLAGE OF KRONENWETTER
MARATHON COUNTY, WI

FILE NO. 8999-100

SHEET 1

ALT 1 FINAL.dgn 3/15/2012 10:22:24 AM ndums



LEGEND

PROPOSED NON-PERFORATED STORM SEWER

PROPOSED PROPERTIES TO BE PROVIDED SUMP CONNECTION

PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: $DATE$	DRAWN BY: AP				
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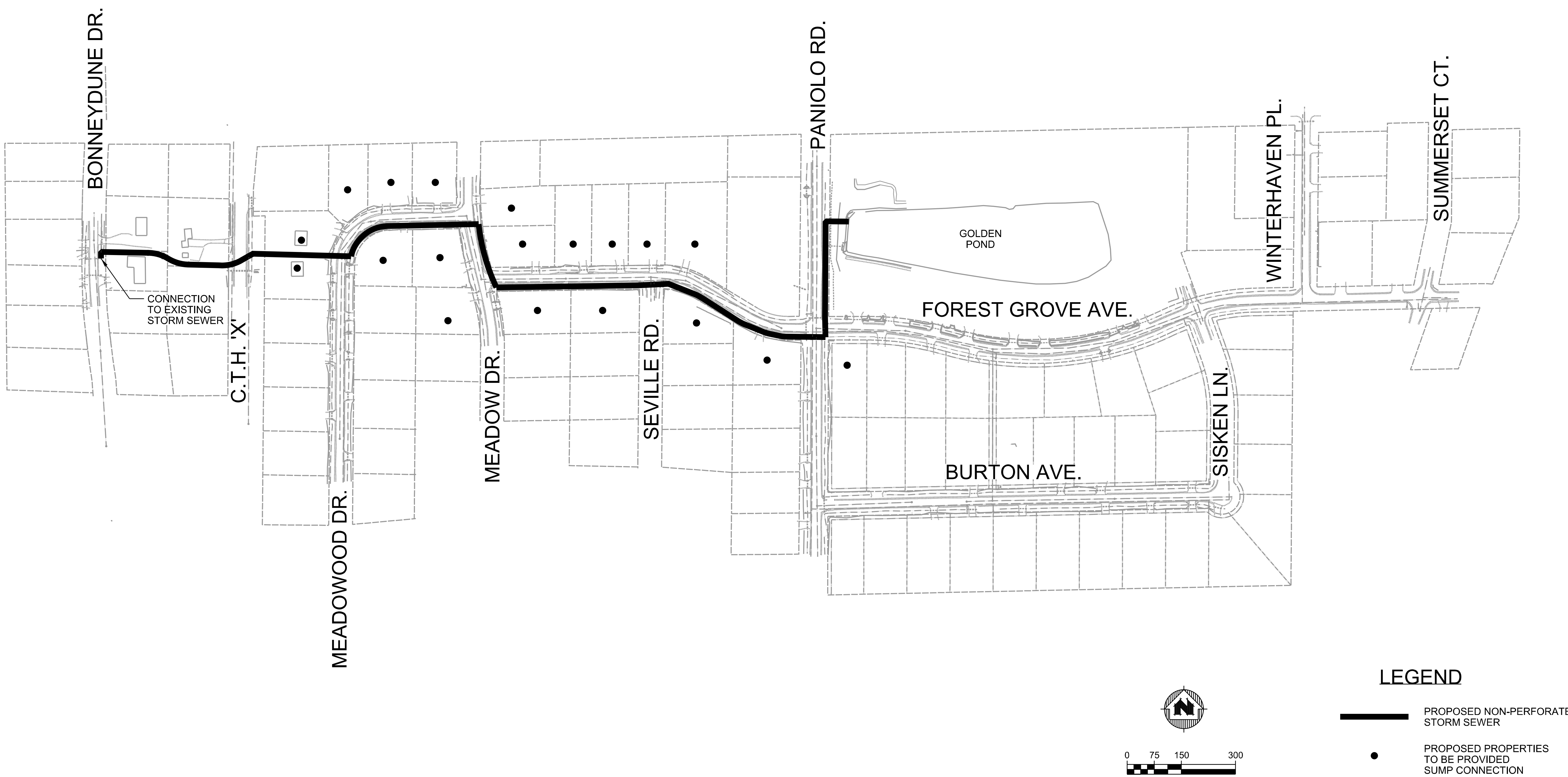
ALTERNATIVE 2

PHASE II DRAINAGE IMPROVEMENTS
VILLAGE OF KRONENWETTER
MARATHON COUNTY, WI

FILE NO. 8999-100

SHEET 2

ALT 2 FINAL.dgn 3/15/2012 10:21:44 AM ndums



PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: $DATE$	DRAWN BY: AP				
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PLOT DATE:					

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Web Address: www.msa-ps.com

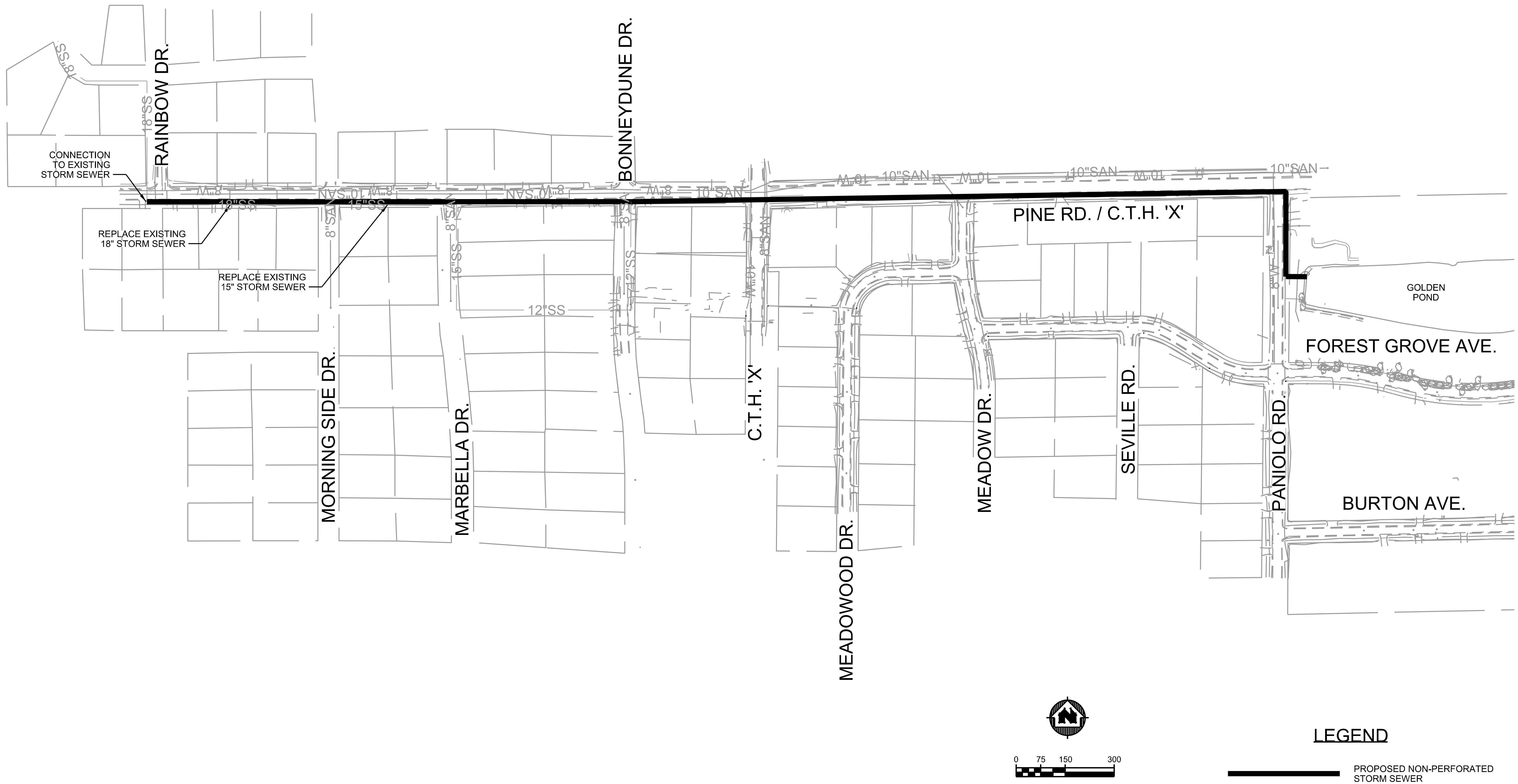
ALTERNATIVE 2

PHASE II DRAINAGE IMPROVEMENTS
VILLAGE OF KRONENWETTER
MARATHON COUNTY, WI

FILE NO. 8999-100

SHEET 2

ALT 2 FINAL.dgn 3/15/2012 10:21:44 AM ndums



PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
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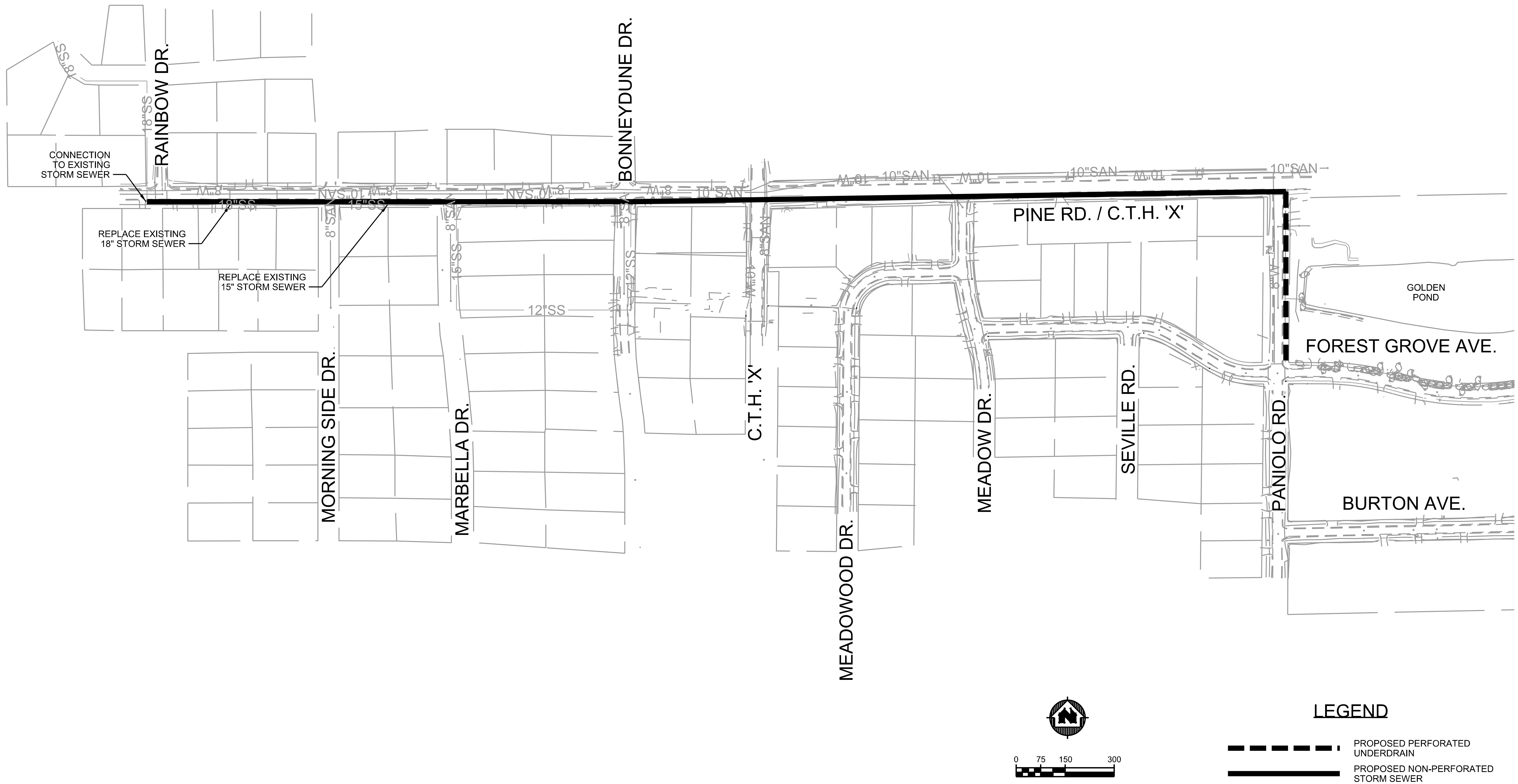
ALTERNATIVE 3

PHASE II DRAINAGE IMPROVEMENTS
VILLAGE OF KRONENWETTER
MARATHON COUNTY, WI

FILE NO. 8999-100

SHEET 3



PROJECT NO.: 08999006	SCALE: AS SHOWN	NO.	DATE	REVISION	BY
PROJECT DATE: $DATE$	DRAWN BY: AP				
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ALTERNATIVE 5

PHASE II DRAINAGE IMPROVEMENTS
VILLAGE OF KRONENWETTER
MARATHON COUNTY, WI

FILE NO. 8999-100

SHEET 5

Village of Kronenwetter
Phase II Drainage Improvements
Preliminary Construction Cost Estimate (Alternative 1)
Prepared by: MSA Professional Services, Inc.
March 2012

Assumptions:
Dewatering is anticipated and costs are estimated in unit prices for underdrain.
Cost of washed stone and wrapped trench is included in unit price for underdrain.
Street restoration consists of 3.5" asphalt over 9" base course.
Concrete driveway restoration consists of 6" concrete over 6" base course.
Asphalt driveway restoration consists of 2" asphalt over 9" base course.
Gravel driveway restoration consists of 12" base course.

Item	*Qty.*	*Units*	*Cost Each*	*Total Cost*
Underdrain				
18-Inch HDPE Underdrain (HDD)	435	LF	$120.00	$52,200.00
18-Inch HDPE Underdrain (Open Cut)	2,235	LF	$44.00	$98,340.00
Manholes	12	EA	$1,800.00	$21,600.00
2-Inch HDPE Near-Side Storm Laterals (Open-Cut)	11	EA	$500.00	$5,500.00
2-Inch HDPE Far-Side Storm Laterals (HDD)	8	EA	$1,500.00	$12,000.00
Connect to Existing Storm Sewer	1	EA	$1,500.00	$1,500.00
Stormwater Control Structure (Bonneydune Drive)	1	LS	$5,000.00	$5,000.00
Water Main Offset/Relocate	3	EA	$3,000.00	$9,000.00
Underdrain Subtotal				***$206,000.00***
Street Work				
Pavement Restoration	865	SY	$20.00	$17,300.00
2-Foot Gravel Shoulder	1,900	LF	$2.50	$4,750.00
Asphaltic Driveway Repair	1	EA	$1,500.00	$1,500.00
Gravel Driveway Repair	2	EA	$500.00	$1,000.00
Culvert Replacement	6	EA	$750.00	$4,500.00
Site Restoration	1	LS	$10,000.00	$10,000.00
Unclassified Excavation	1	LS	$8,000.00	$8,000.00
Erosion Control	1	LS	$5,000.00	$5,000.00
Traffic Control	1	LS	$3,500.00	$3,500.00
Street Work Subtotal				***$56,000.00***
Estimated Construction Cost				**262,000.00**
Contingencies (10% Construction)				**27,000.00**
Study/Design Cost, Amendments #1 & #2				**57,800.00**
Construction Administration/Observation Cost				**27,000.00**
Total Estimated Project Cost				**$373,800.00**

Village of Kronenwetter
Phase II Drainage Improvements
Preliminary Construction Cost Estimate (Alternative 2)
Prepared by: MSA Professional Services, Inc.
March 2012

Assumptions:
Dewatering is anticipated and costs are estimated in unit prices for storm sewer.
Street restoration consists of 3.5" asphalt over 9" base course.
Asphalt driveway restoration consists of 2" asphalt over 9" base course.
Gravel driveway restoration consists of 12" base course.

Item	*Qty.*	*Units*	*Cost Each*	*Total Cost*
Storm Sewer				
18-Inch HDPE Storm Sewer (HDD)	435	LF	$120.00	$52,200.00
18-Inch HDPE Storm Sewer (Open Cut)	2,180	LF	$39.00	$85,020.00
Manholes	9	EA	$1,800.00	$16,200.00
2-Inch HDPE Near-Side Storm Laterals (Open-Cut)	12	EA	$500.00	$6,000.00
2-Inch HDPE Far-Side Storm Laterals (HDD)	10	EA	$1,500.00	$15,000.00
Connect to Existing Storm Sewer	1	EA	$1,500.00	$1,500.00
Storm Water Control Structure (Golden Pond)	1	LS	$3,000.00	$3,000.00
Storm Water Control Structure (Bonneydune Drive)	1	LS	$5,000.00	$5,000.00
Storm Sewer Subtotal				***$184,000.00***
Street Work				
Pavement Restoration	865	SY	$20.00	$17,300.00
2-Foot Gravel Shoulder	1,900	LF	$2.50	$4,750.00
Asphaltic Driveway Repair	1	EA	$1,500.00	$1,500.00
Gravel Driveway Repair	2	EA	$500.00	$1,000.00
Culvert Replacement	6	EA	$750.00	$4,500.00
Site Restoration	1	LS	$10,000.00	$10,000.00
Unclassified Excavation	1	LS	$8,000.00	$8,000.00
Erosion Control	1	LS	$5,000.00	$5,000.00
Traffic Control	1	LS	$3,500.00	$3,500.00
Street Work Subtotal				***$56,000.00***
Estimated Construction Cost				**$240,000.00**
Contingencies (10% Construction)				**$24,000.00**
Study/Design Cost, Amendments #1 & #2				**$57,800.00**
Construction Administration/Observation Cost				**$24,000.00**
Total Estimated Project Cost				**$345,800.00**

Village of Kronenwetter
Phase II Drainage Improvements
Preliminary Cost Estimate (Alternative 3)
Prepared by: MSA Professional Services, Inc.
March 2012

Assumptions:
Dewatering is anticipated and costs are estimated in unit prices for storm sewer.
County highway restoration consists of 4" asphalt over 12" base course.
Village street restoration consists of 3.5" asphalt over 9" base course.
Asphalt driveway restoration consists of 2" asphalt over 9" base course.
Gravel driveway restoration consists of 12" base course.

Item	*Qty.*	*Units*	*Cost Each*	*Total Cost*
Storm Sewer				
18-Inch HDPE Storm Sewer (Open Cut)	2,720	LF	$39.00	$106,080.00
18-Inch HDPE Storm Sewer (HDD)	70	LF	$120.00	$8,400.00
18-Inch RCP Storm Sewer (Open Cut)	500	LF	$48.00	$24,000.00
Manholes	13	EA	$1,800.00	$23,400.00
Connect to Existing Storm Sewer	3	EA	$1,500.00	$4,500.00
Stormwater Control Structure (Golden Pond)	1	LS	$3,000.00	$3,000.00
Water Main Offset/Relocate	2	EA	$3,000.00	$6,000.00
Storm Sewer Subtotal				***$176,000.00***
Street Work				
Pavement Restoration (CTH X)	770	SY	$25.00	$19,250.00
Pavement Restoration (Village Streets)	390	SY	$20.00	$7,800.00
2-Foot Gravel Shoulder	3,640	LF	$2.50	$9,100.00
Asphaltic Driveway Repair	9	EA	$1,500.00	$13,500.00
Gravel Driveway Repair	3	EA	$500.00	$1,500.00
Culvert Replacement	13	EA	$750.00	$9,750.00
Site Restoration	1	LS	$12,500.00	$12,500.00
Unclassified Excavation	1	LS	$20,000.00	$20,000.00
Erosion Control	1	LS	$8,000.00	$8,000.00
Traffic Control	1	LS	$10,000.00	$10,000.00
Street Work Subtotal				***$112,000.00***
Estimated Construction Cost				**$288,000.00**
Contingencies (10% Construction)				**$29,000.00**
Study/Design Cost, Amendments #1 & #2				**57,800.00**
Construction Administration/Observation Cost				**$29,000.00**
Total Estimated Project Cost				**$404,000.00**

Village of Kronenwetter
Phase II Drainage Improvements
Preliminary Cost Estimate (PIC Recommended Alternative 4)
Prepared by: MSA Professional Services, Inc.
March 2012

Assumptions:
Dewatering is anticipated and costs are estimated in unit prices for storm sewer.
County highway restoration consists of 4" asphalt over 12" base course.
Village street restoration consists of 3.5" asphalt over 9" base course.
Asphalt driveway restoration consists of 2" asphalt over 9" base course.
Gravel driveway restoration consists of 12" base course.

Item	*Qty.*	*Units*	*Cost Each*	*Total Cost*
Storm Sewer				
18-Inch HDPE Storm Sewer (Open Cut)	2,720	LF	$39.00	$106,080.00
18-Inch HDPE Storm Sewer (HDD)	70	LF	$120.00	$8,400.00
18-Inch RCP Storm Sewer (Open Cut)	500	LF	$48.00	$24,000.00
12-Inch HDPE Underdrain (Open Cut)	800	LF	$39.00	$31,200.00
Manholes	16	EA	$1,800.00	$28,800.00
Connect to Existing Storm Sewer	3	EA	$1,500.00	$4,500.00
Stormwater Control Structure (Golden Pond)	1	LS	$3,000.00	$3,000.00
Water Main Offset/Relocate	2	EA	$3,000.00	$6,000.00
Storm Sewer Subtotal				***$212,000.00***
Street Work				
Pavement Restoration (CTH X)	770	SY	$25.00	$19,250.00
Pavement Restoration (Village Streets)	520	SY	$20.00	$10,400.00
2-Foot Gravel Shoulder	4,240	LF	$2.50	$10,600.00
Asphaltic Driveway Repair	12	EA	$1,500.00	$18,000.00
Gravel Driveway Repair	3	EA	$500.00	$1,500.00
Culvert Replacement	16	EA	$750.00	$12,000.00
Site Restoration	1	LS	$14,500.00	$14,500.00
Unclassified Excavation	1	LS	$23,000.00	$23,000.00
Erosion Control	1	LS	$9,000.00	$9,000.00
Traffic Control	1	LS	$10,000.00	$10,000.00
Street Work Subtotal				***$129,000.00***
Estimated Construction Cost				**$341,000.00**
Contingencies (10% Construction)				**$35,000.00**
Study/Design Cost, Amendments #1 & #2				**57,800.00**
Construction Administration/Observation Cost				**$35,000.00**
Total Estimated Project Cost (PIC Recommended Alternative 4)				**$469,000.00**

Village of Kronenwetter
Phase II Drainage Improvements
Preliminary Cost Estimate (Alternative 5)
Prepared by: MSA Professional Services, Inc.
March 2012

Assumptions:
Dewatering is anticipated and costs are estimated in unit prices for storm sewer.
County highway restoration consists of 4" asphalt over 12" base course.
Village street restoration consists of 3.5" asphalt over 9" base course.
Asphalt driveway restoration consists of 2" asphalt over 9" base course.
Gravel driveway restoration consists of 12" base course.

Item	*Qty.*	*Units*	*Cost Each*	*Total Cost*
Storm Sewer				
18-Inch HDPE Storm Sewer (Open-Cut)	2,390	LF	$39.00	$93,210.00
18-Inch HDPE Storm Sewer (HDD)	70	LF	$120.00	$8,400.00
18-Inch RCP Storm Sewer (Open Cut)	500	LF	$48.00	$24,000.00
18-Inch HDPE Underdrain (Open-Cut)	500	LF	$44.00	$22,000.00
Manholes	14	EA	$1,800.00	$25,200.00
Connect to Existing Storm Sewer	3	EA	$1,500.00	$4,500.00
Stormwater Control Structure (Rainbow Drive)	1	LS	$5,000.00	$5,000.00
Water Main Offset/Relocate	2	EA	$3,000.00	$6,000.00
Storm Sewer Subtotal				***$189,000.00***
Street Work				
Pavement Restoration (CTH X)	770	SY	$25.00	$19,250.00
Pavement Restoration (Village Streets)	440	SY	$20.00	$8,800.00
2-Foot Gravel Shoulder	3,640	LF	$2.50	$9,100.00
Asphaltic Driveway Repair	9	EA	$1,500.00	$13,500.00
Gravel Driveway Repair	3	EA	$500.00	$1,500.00
Culvert Replacement	13	EA	$750.00	$9,750.00
Site Restoration	1	LS	$12,500.00	$12,500.00
Unclassified Excavation	1	LS	$20,000.00	$20,000.00
Erosion Control	1	LS	$8,000.00	$8,000.00
Traffic Control	1	LS	$10,000.00	$10,000.00
Street Work Subtotal				***$113,000.00***
Estimated Construction Cost				**$302,000.00**
Contingencies (10% Construction)				**$31,000.00**
Study/Design Cost, Amendments #1 & #2				**57,800.00**
Construction Administration/Observation Cost				**$31,000.00**
Total Estimated Project Cost				**$422,000.00**