Prairie Creek Treatment Train Schematic Design Narrative

Project Description

The Prairie Creek Treatment Train (PCTT) intends to address nutrient loading into Grand Lake St. Marys GLSM through removal of bed load, and treatment of base flow and storm water discharges. The Prairie Creek watershed drains 2,310 acres of which 95% is in agricultural production (Figure 1). In-situ loading studies from adjacent drainages indicate a total phosphorus loading between 0.32 and 0.63ppm. The PCTT will treat flows from the drainage via a series of interlinked treatment systems before discharge into GLSM. The elements of the PCTT treatment train include (Figure 2):

1. **Bed Load Collection/Flocculation- (319 Grant Funded)**

   Design Concept
   A bed load collector will be installed in Prairie Creek above the backwater influence of GLSM. During storm events, this collector system will collect bed load and use the energy of the stream to move bed load sediment up the collector's ramp and into a hopper. Once the hopper is full, the sediment will be pumped to a dewatering area for collection and disposal. The conveyance water will be returned to the creek via a swale with integrated flocculent application stations to manage suspended particulates.

   Design Criteria Elements
   Bed Load Composition

Suspended Load	12mg/l
D16	1.2 mm
D35	1.2 mm
D50	1.2 mm
D84	3.2 mm
D95	5.2 mm

Q Max Sediment Yield	200 CFS
Max Sediment Yield Event Duration	24 hours

   Design Solution
   The collector will be located outside of the backwater effect of GLSM. The cross sectional area of the channel will be modified to provide the optimum depth and velocity for collection of the bed load composition in the channel. The design will focus on the use or re-use of Streamside Systems sediment collector. Critical conditions for operation of the unit are relatively low flow depths with relatively high velocities. These conditions have been shown to cause clogging of the system. Removal efficiencies for bed load

material above 0.25mm was >80% with efficiency increasing proportionally with grain size. The cross sectional area of the channel at the point of deployment will be modified to maintain velocities < 3 ft/sec but above shear required to move the D95 during the Q Max discharge on the Flow Duration Sediment Rating Curve (approximately 200 CFS).

Sediment will be transferred from the collector by pumping with channel water serving as a conveyance medium at 1 CFS. Sediment will be pumped through Geo-tubes to separate material from conveyance water. Discharge water will be routed through a solid PAC dosing zone and into a 200’ long swale for settlement of suspended load, prior to returning to Prairie Creek. The sediment and suspended load collection area will be sized to treat the loading from 61,500 CF of water over a 24 hour period. Access and composition structure will be established to allow efficient clean out.

Probable Estimate of Cost

Construction	$50,000
Operation/year	
Materials	$2,000
Electric	$1,000
Maintenance/Clean out	$2,000

2. **Draw Line and Lift Station – (319 Grant Funded)**

Design Concept

Delivery of raw water for treatment to the main components of the system will be accomplished through a draw line and lift station. A water control structure will be established at the intersection of the free flow of Prairie Creek and the backwater of GLSM. This positioning will enable collection of base flow and storm flows from the watershed, or the in situ treatment of lake water in the event drought conditions decrease the base flows below the treatment capacity of the system, fully utilizing the annual treatment capacity of the system.

Design Criteria Elements

Inflow Rate	
Min	0.2 CFS
Max	2 CFS
Draw Distance	
Vertical	8 ft
Horizontal	2000 ft

Design Solution

A 15" conduit will convey the creek/lake water 2016 feet by gravity to a wet-well and lift station. A ???? HP electric pump will lift the water 20' through an 8" conduit into the dosing basins.

Probable Estimate of Cost

Construction	$85,000
Operation/year	
Electric	$2,500
Maintenance	$3,000

3. **Alum and Chitosan Dosing** – (**USDA Grant Funded**)

Design Concept

Removal of particulate and dissolved phosphorus will be aided by the addition of dosing basins in advance of the constructed wetlands component to improve the efficiency of the wetlands.

Design Criteria Elements

Average P Concentration of Input Water	0.47 ppm
Minimum Contact Time	20 minutes
Average P Concentration of Output Water	0.20 ppm
Inflow Rate	
Min	0.2 CFS
Max	2 CFS
Operational Term	280 days/year

Design Solution

Two treatment chambers will be incorporated in advance of the wetland systems. The first chamber will apply Chitosan to precipitate suspended sediment. The second chamber will apply alum to precipitate dissolved phosphorus. Dosing will be regulated by a flow proportional pump and precipitates will be collected and removed for disposal. Each basin has been sized to allow for a minimum of 20 minutes of contact time prior to discharge.

Probable Estimate of Cost

Construction	$100,000
Operation/year	
Materials	$15,000
Electric	$ 1,000
Maintenance/Clean Out	$ 2,500

4. **Constructed Wetlands – (319 Grant Funded)**

Design Concept

A constructed wetland will be created off line to biologically process and assimilate phosphorus loadings and allow de-nitrification. The constructed wetland will be planted with persistent emergent species proven to be efficient at assimilating nutrients. The wetland will be designed to accommodate a portion of the base flow from the system as well as the "first flush" of storm event runoff from storm events ranging in size from 0.1" to 1.0". Larger events will bypass the system via Prairie Creek.

Design Criteria Elements

Hydraulic Loading	.75 to 1.25"/week
Phosphorous Loading capacity	1g P/SM/year
Average P Concentration of Input Water	0.47 ppm
Operational Term	280 days/year
Overall Total Area	6.7 acres
High Marsh Total Area	4.4 acres
Low Marsh Total Area	0.7 acres
Open Water Total Area	0.8 acres
Subsurface-Flow Total Area	0.2 acres
Average Detention Times	1.6 days @ 2 cfs
	14 days @ 0.2 cfs
Velocity Range	0.003 – 0.03 fps

Design Solution

The wetland will initiate in a XXX acre, xx-feet deep forebay to capture any solids not removed in the sediment settling basins preceding the wetland. The fore bay discharges to a series of wetland zones each comprised of areas of 6-inch, 12-inch and 24-inch depths. The of 6-inch, 12-inch areas within each zone function as low marshes and high marshes, respectively and will support various plants types with the primary species being the various types of bulrush. Bulrush species have been shown to provide an environment for the conversion of ammonia to nitrate. The 24-inch zones will remain primarily open water to add in atmospheric transfer of oxygen to the water and provide areas for the deposit phosphorous containing plant litter.

The system has two points of release that may be used; one which will release to a wetland restoration area and a second to the existing riparian wetlands. Each release point will have an 18" deep gravel bed area thru which all flow must pass. The gravel beds will function as subsurface-flow wetlands and allow for enough reduction in oxygen to assist in the conversion of nitrates to nitrogen gas. Overall water depth of the wetland zones will be adjustable at each outlet by level control structures.

Probable Estimate of Cost

Construction	$181,000
Operation	
Maintenance	$5,000

5. **Wetland Restoration – (319 Grant Funded)**

Design Concept

Prior to return to the lake, the treated water will be routed through a restored or enhanced riparian wetland area. The restored wetland will include emergent, forested and scrub shrub components to maximize diversity.

Design Criteria Elements

Plantings		
	Trees	640 stems/acre
	Shrubs	200 stems/acre
	Emergent	60% aerial coverage
Hydrology		>20% of Growing season

Design Solution

Fill will be removed and the land shaped to create micro-topography to maximize residence time in the wetland. Supplemental hydrology will be provided by incorporating the release of water originating in the constructed wetland. The area will be re-seeded and planted with native wetland species. A peripheral berm will be created on the southern edge of the site to screen the site from the adjacent residences, and maintain access around the site for maintenance, educational and recreation activities.

Probable Estimate of Cost

Construction	$120,000

6. **Embayment – (319 Grant Funded)**

Design Concept

Treated water from the created and restored wetland areas will enter the embayment area of GLSM. In order to better isolate the embayment for water quality improvement projects shallow berms will be created to effectively subrogate the embayment from the main body of the lake. The shallow berms will be designed to interact with GLSM, however the interaction will be significantly reduced from its current condition. The new, more isolated embayment will allow for the deployment of additional embayment water quality improvement features listed below. It is anticipated that the shallow berms will also provide a breakwater effect that will provide erosion control benefits along the embayment shoreline.

Design Criteria Elements

Design Storm	25 year
Wind Speed	65 MPH
Duration	0.35 hours
Max Fetch Distance	23,300 ft
Max Wave Height	2.5’
Section	
Min Elevation	872’ ±
Min Width	16 ft

Design Solution

The embayment will be created by the placement of a perimeter berm of Geo-tubes filled with sediment. Sub-grade will be prepared by removing accumulated silts and fines until consolidated bed material is encountered. Material will be pumped into the geotube(s) to create the section. The windward side of each berm will be protected with rock or a transition slope suitable to negate the anticipated wave energies.

Probable Estimate of Cost

Construction	$150,000
Operation	
Maintenance	$2,000

7. **Floating Wetland Islands – (319 Grant Funded)**

Design Concept

Floating wetland islands will be installed as an additional treatment mechanism within the embayment. Floating wetland islands are highly functional, non-traditional floating wetland systems with open root architecture that provide an extremely large surface area for nutrient sequestration when populated with indigenous wetland flora. Engineered floating wetlands have been demonstrated to have significant positive impacts on water quality through nutrient uptake by microbial transformation; macrophyte assimilation; absorption into organic and inorganic substrate; and even volatilization. One key to success of the complex microbial systems is the significant surface area upon which diverse microbial population can contact the water column. The floating wetland architecture proposed for this implementation maximizes contact of the wetland flora root zone in the water column (hydroponically) for uptake of mineral nutrients as inorganic ions as well as a massive surface area for microbial colonization. What differentiates a floating island from a terrestrial or engineered wetland is the ability to easily harvest the plant biomass, on which, and in which, additional nutrients are fixed from indigenous wetland flora. The design of the islands may also make it possible to repeatedly harvest and compost the biomass throughout the growing season, thereby maximizing nutrient uptake and removal from the water economy. Furthermore, the islands can provide additional amenities such shade, an important ingredient for certain fish spawning areas, energy dissipation for wind and wave energy and mobile littoral zones for engineered (armored) or eroding shorelines. This component of the treatment train is focused on demonstrating that non-traditional floating wetlands are capable of extracting phosphorus, nitrates, and other nutrients out of the water column, thus outcompeting blue-green algae for available nutrients thereby reducing their prevalence in the water column and limiting microcystin and other potential toxin related events.

Design Criteria Elements

Design Storm	10 year
Wind Speed	57 MPH
Duration	0.35 Hours
Max Fetch Distance	1,200 ft
Max Wave Height	1 ft
Aerial Coverage	20%
Plant Density	2/SF
Species Diversity	5
Operational Term	1 Year

Design Solution

A floating wetland capable of seasonal deployment and removal with a minimum 5 year life cycle for the floating wetland structural elements will be deployed. It will be maintained in place via an anchoring system within the designated floating wetland zone within the embayment. The components will have the ability to be deployed in multiple geometries (modular) and be configured and re-configured to accommodate site without structural modification and allow for component installation, replacement and removal of plantings in standardized nursery plug sizes, during operation at a minimum density of 2 plants/sq. ft. A minimum 5 different species of herbaceous plants of local genotype/origin grown in a soil-less medium to a 4" height with adequate root density will be utilized.

The system will provide a minimum 10% aerial coverage of the floating wetland area with viable, actively growing plant material in single or multiple wetlands and will maximize microbial colonization by providing a floating island matrix that will be highly permeable (minimum 90% void space, maximum 10% polymer matrix fibers) and resistant to environmental degradation.

Probable Estimate of Cost

Construction	$48,000
Operation	$N/A

Summary of Construction and Operational Costs

Design Element	Construction Cost	Funding Source	Yearly Operation
Bed Load Collection/Flocculation	$50,000	319	$4,000
Draw Line and Lift Station	$85,000	319	$5,500
Alum and Chitosan Dosing Basins	$100,000	USDA	$18,500
Constructed Wetlands	$181,000	319	$5,000
Wetland Restoration	$120,000	319	$0
Embayment	$150,000	ODNR	$2,000
Floating Wetland Islands	$48,000	319	$5,000
Total	**$734,000**		**$40,000**

Construction Funding

Source	Amount
2010 319 Grant Funds	$484,000
USDA Grant	$100,000
ODNR In-kind Match	$150,000

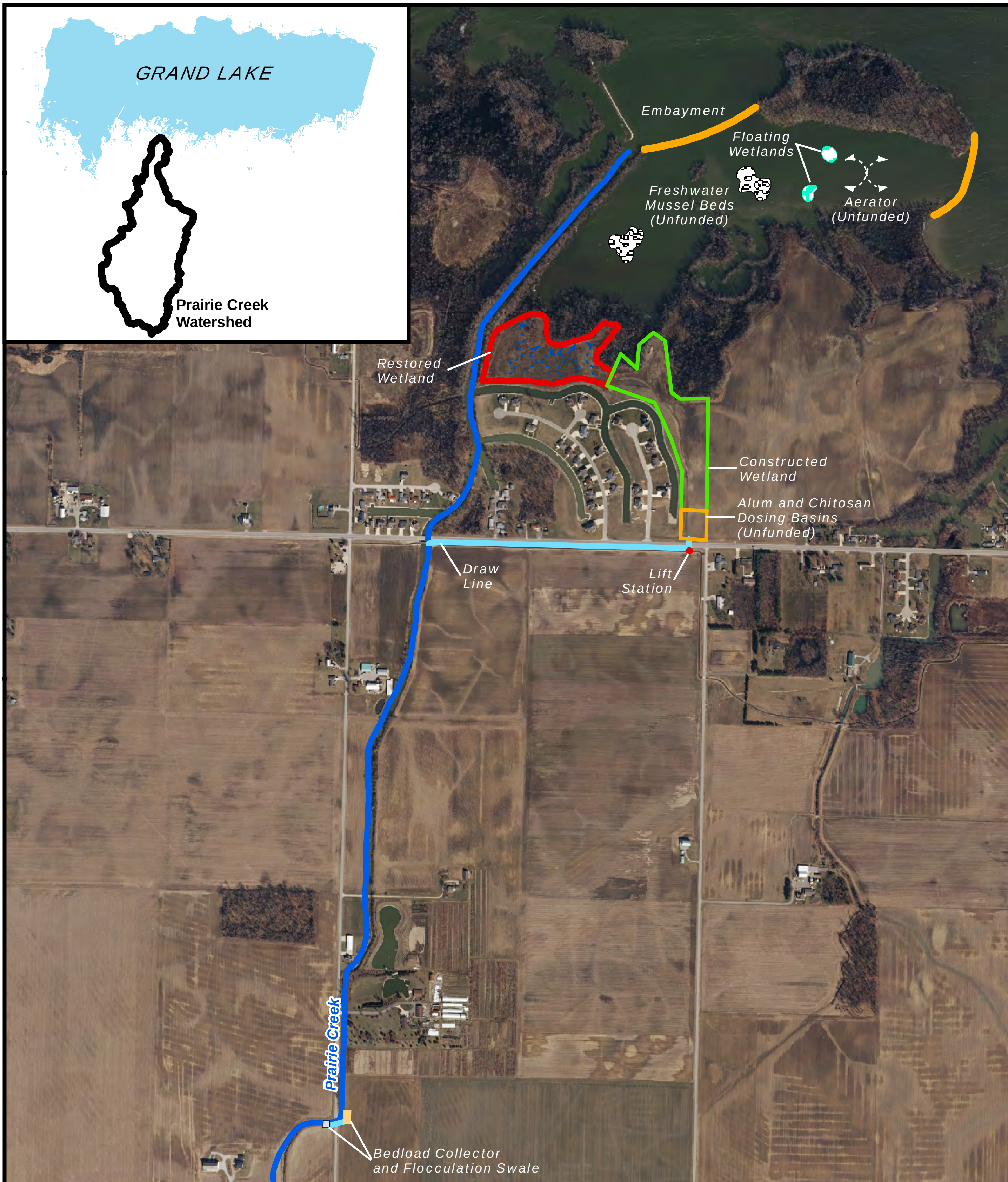
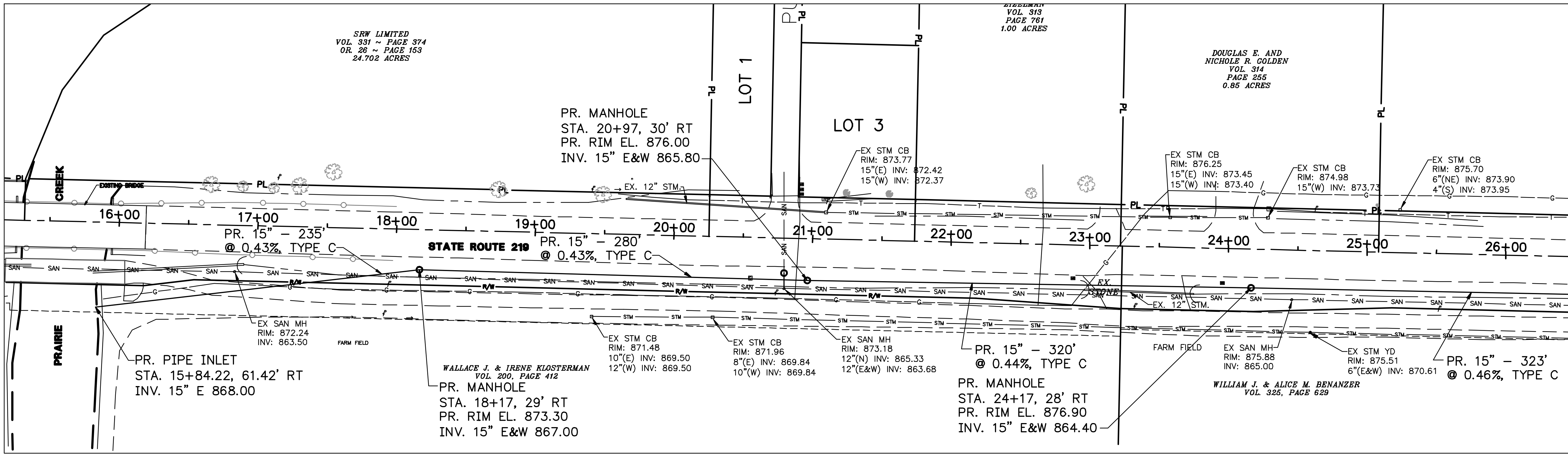


Figure 2. Prairie Creek Treatment Train Components

Image Source: Mercer County Orthoimagery, 2009.
Map projected in Ohio State Plane North NAD83.
Map created 5/11/2011.

1,000 500 0 1,000
Feet

N



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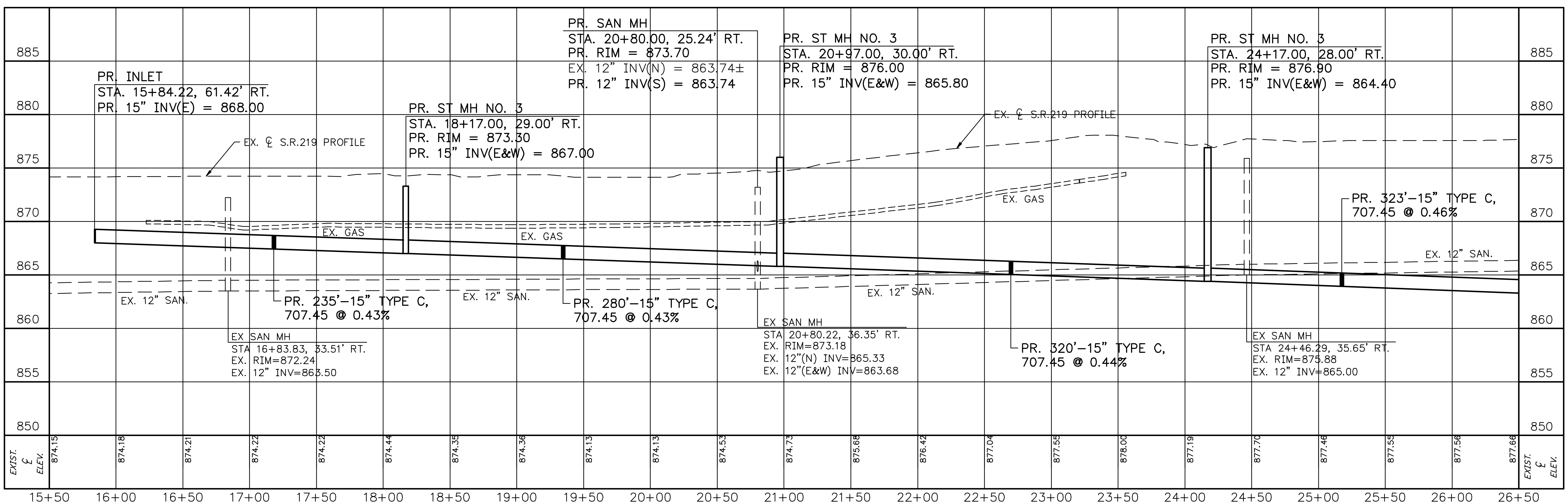

KCI JOB NUMBER 20110259B

DRAWN	CHECKED	DATE
REG	--	04/11

0' 20' 40' 80'

PRAIRIE CREEK TREATMENT TRAIN

WATER CONTROL STRUCTURE PLAN & PROFILE - S.R. 219 STA. 15+20 TO STA. 26+50

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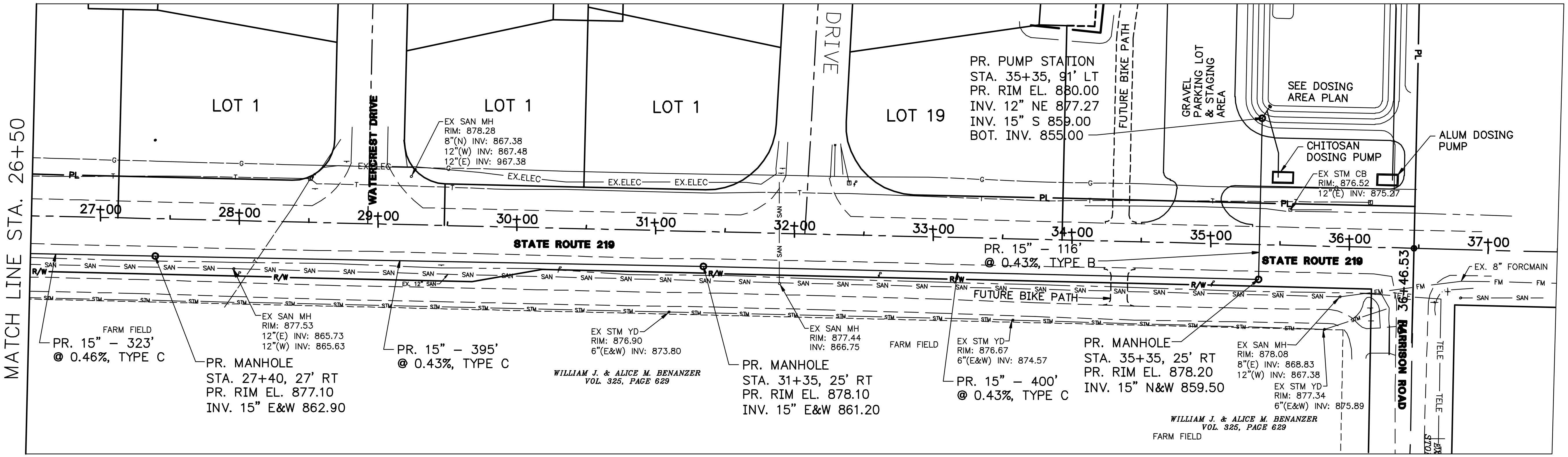

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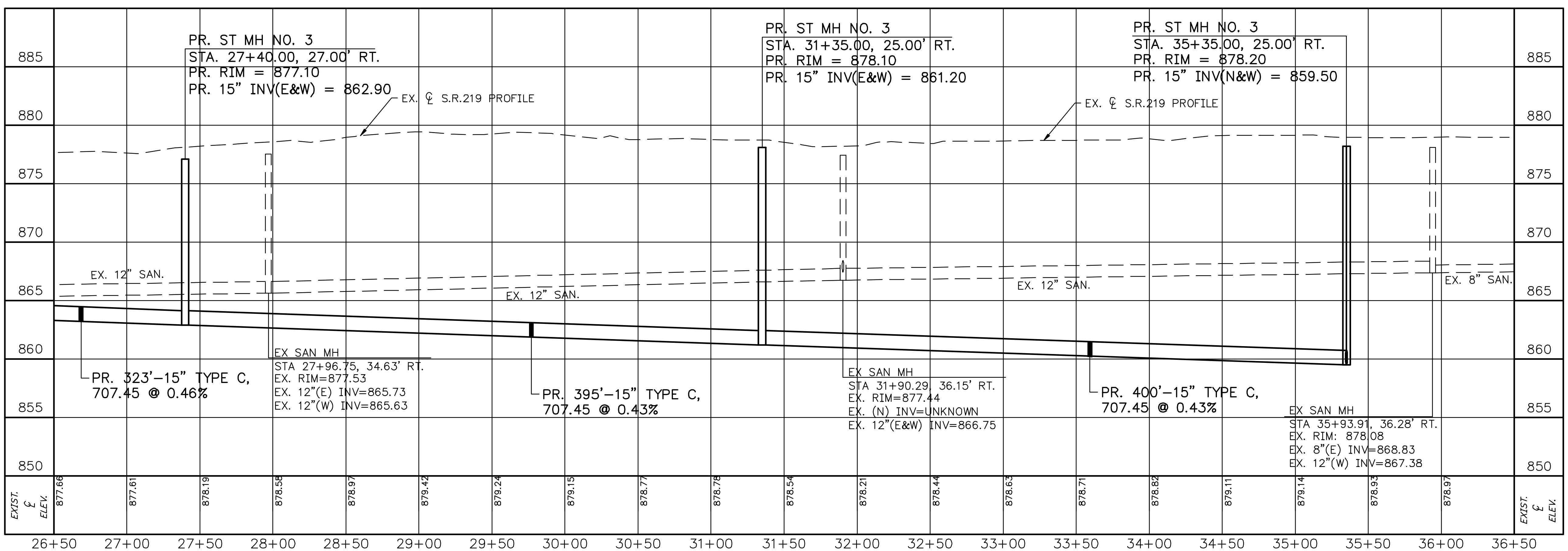

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KCI JOB NUMBER 20110259B
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0' 20' 40' 80'

PRAIRIE CREEK TREATMENT TRAIN

WATER CONTROL STRUCTURE PLAN & PROFILE - S.R. 219 STA. 26+50 TO STA. 37+50

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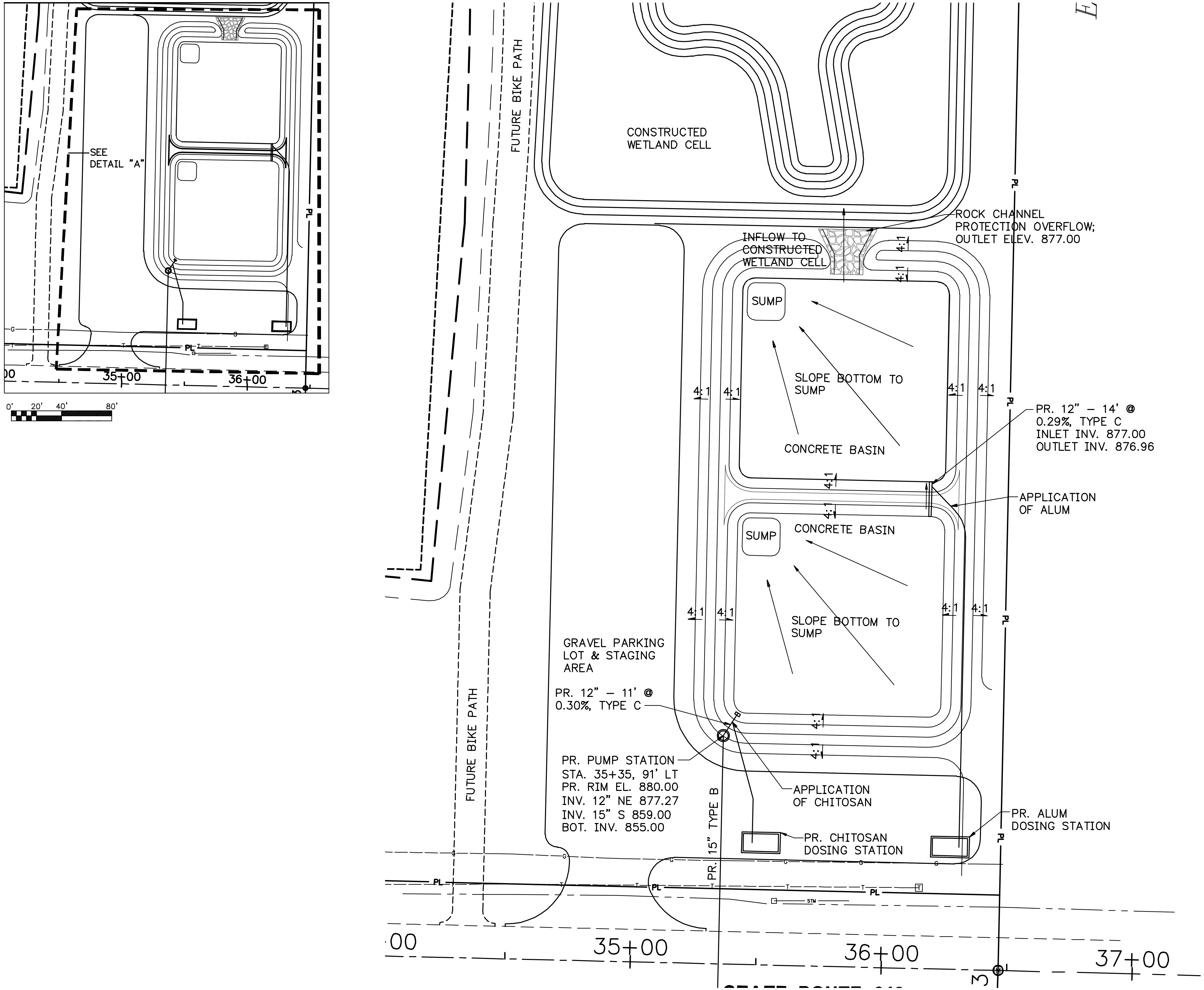
MATCH LINE TO CONSTRUCTED WETLANDS



DETAIL "A"

CONTRACT "A" INCLUDES:
a. WATER CONTROL STRUCTURE
b. PUMP & ELECTRIC, INCLUDING ALL ASSOCIATED PIPING & FITTINGS
c. BED SEDIMENT COLLECTOR
d. GRAVEL PARKING LOT
e. TWO SEDIMENT BASINS, EXCAVATION & EMBANKMENT
f. CONSTRUCTED WETLANDS
g. RESTORED WETLANDS

CONTRACT "B" INCLUDES:
a. CHITOSAN DOSING STATION, INCLUDING ELECTRIC
b. ALUM DOSING STATION, INCLUDING ELECTRIC

KCI JOB NUMBER 20110259B
DRAWN REG | CHECKED -- | DATE 04/11
0' 10' 20' 40'

PRAIRIE CREEK TREATMENT TRAIN

DOSING AREA PLAN

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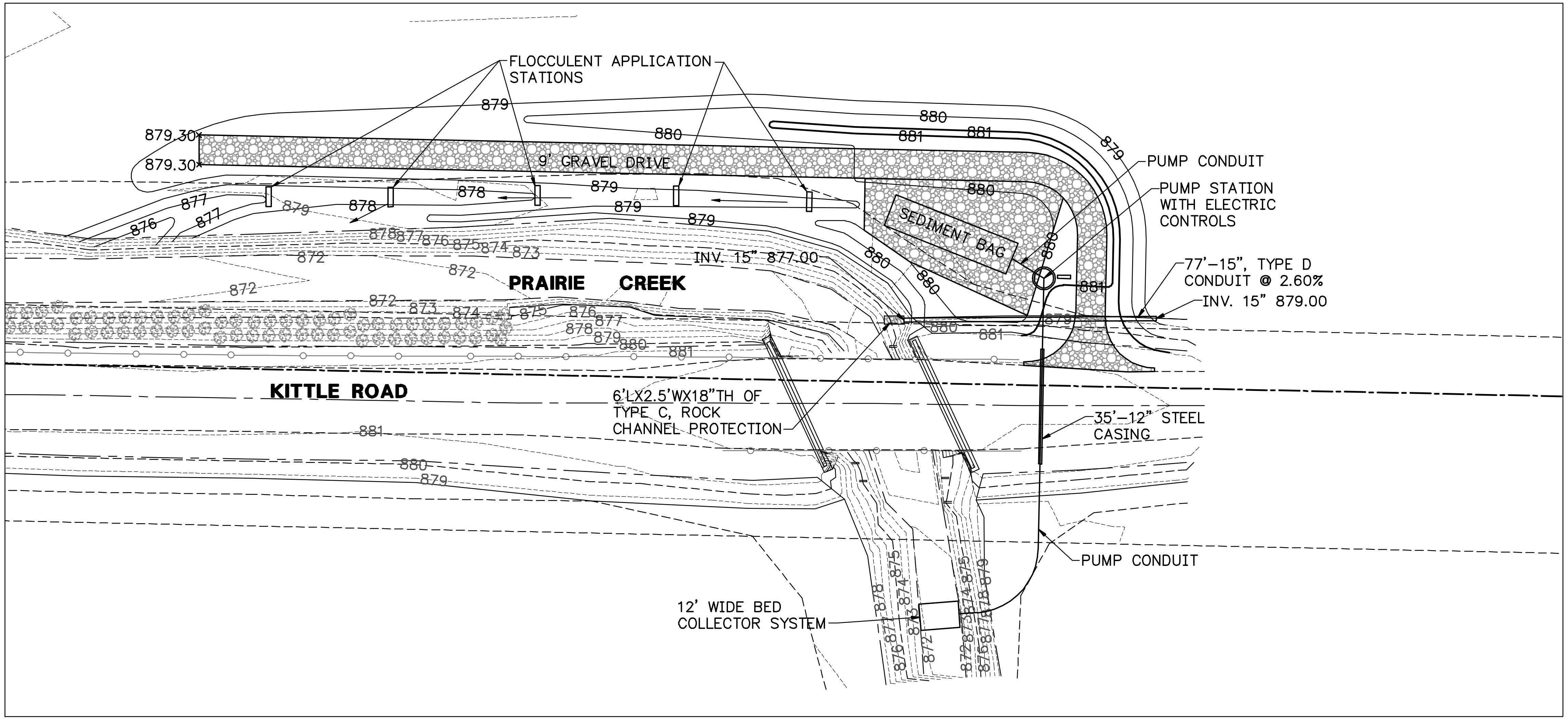
ITEM 411 – 8" STABILIZED CRUSHED AGGREGATE



<u>THIS PART OF THE PROJECT CONSISTS OF THESE THREE ELEMENTS:</u>

1. ELECTRIC COORDINATION, PERMIT AND SERVICE
2. SEDIMENT COLLECTOR SYSTEM (AS PER STREAMSIDE SYSTEMS, LLC.), INCLUDING:
   a. SEDIMENT COLLECTOR, 12' WIDE
   b. PULL OFF: D50 = 1.2mm; D84 = 3.2mm; D95 = 5.2mm
   c. Qmax: 200CFS
   d. MAXIMUM SEDIMENT YIELD EVENT DURATION: 24 HOURS
   e. POWER, MOTOR CONTROL
   f. FLOW CONTROL, SEDIMENT BAY
   g. PUMP & ALL ASSOCIATED PIPING & FITTINGS (TOTAL HEAD SHALL NOT EXCEED)
   h. INTEGRATED FLOCCULENT APPLICATION STATIONS
3. SITE WORK
   a. GRADING, EXCAVATION, EMBANKMENT
   b. GRAVEL DRIVE
   c. SEDIMENT BAG AREA
   d. ALL GRAVEL
   e. 12" STEEL CASING
   f. 15" CULVERT & ROCK CHANNEL PROTECTION

KCI JOB NUMBER 20110259B

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0' 10' 20' 40'

PRAIRIE CREEK TREATMENT TRAIN

BED LOAD COLLECTION AREA – PRAIRIE CREEK & KITTLE ROAD

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Perpetual Channel Easement granted to the Ohio Department of Natural Resources
PRAIRIE VIEW DRIVE
AQUA DRIVE
WATERCREST DRIVE
PRAIRIE CREEK SUB-DIVISION PLAT BOOK 9 ~ PAGE 37
PUBLIC STREET
AQUA VIEW ESTATES PHASE III PLAT CABINET 3 PAGE 39
EAST LINE OF THE NORTHEAST QUARTER OF SECTION 21
0'
50'
100'
200'