



Consulting
Engineers and
Scientists



Muskegon Lake Nature Preserve

Herpetofauna Report

Submitted to:

West Michigan Shoreline Regional Development Commission

Submitted by:

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Introduction

In support of the delisting of the Muskegon Lake Area of Concern (AOC), the West Michigan Shoreline Regional Development Commission (WMSRDC) worked with GEI Consultants of Michigan, P.C. (GEI) and the Muskegon Environmental Research and Education Society (MERES) to design and implement ecological restoration efforts at the Muskegon Lake Nature Preserve (Appendix A). The restoration efforts were funded in partnership with the National Oceanic and Atmospheric Administration (NOAA) and the Great Lakes Commission (GLC), and included wetland creation, debris removal, hydrologic reconnection, the creation of pollinator habitat, and invasive species control throughout the preserve.

Herpetofaunal surveys were completed before and after the restoration efforts were implemented to gauge the potential benefit of the restoration efforts to herpetofauna at the site. During the spring of 2019 and 2021, and summer of 2019, 2021, and 2022, experienced GEI biologists conducted herpetofauna (amphibian and reptile) surveys throughout the Muskegon Lake Nature Preserve (MLNP) to evaluate how herpetofauna populations responded to the restoration efforts implemented (Figure 1). A minimum of three (3) surveys were conducted each year during appropriate weather conditions. Multiple survey methods were implemented to maximize herpetofauna detection.

1. Methods

Monitoring focused on the areas that were restored and the adjacent wetland communities. The survey methods utilized are described below.

1.1 Acoustic Surveys

The acoustic survey sampling methodology mimicked those established by the Bird Studies Canada, Marsh Monitoring Program (MMP; MMP, 2008). Aural (hearing-based) surveys were used to detect and record the presence and relative abundance for calling amphibians (toads and frogs). The data was collected on MMP – Amphibian Data Form. Survey locations are shown in Figure 1.

Surveys began at least one half-hour after sunset and were completed by midnight during evenings with little wind and minimum night air temperatures of 5C (41°F), 10C (50°F) and 17C (63°F), for each of the three respective survey periods (MMP, 2008).

Marsh Monitoring Program – Amphibian Data Forms (MMP, 2008) were used to record data during each survey period. A three (3) minute survey was conducted at each of the two (2) monitoring stations (east and west) using an unlimited distance semi-circular sampling area. However, to associate calls heard within the defined 100-meter (110 yard) area, surveyors were asked to ascertain and record whether calls were heard outside the 100-meter (110 yard) radius or within this radius.

Call level codes were assigned to all calling frog and toad species following the MMP protocol (MMP, 2008).

1.2 Dip Net Surveys

Dip net surveys were conducted within a ponded area located in the south-central portion of the project site to determine presence of herpetofauna in early life stages. GEI staff conducted meander surveys within the pond using dip nets to sample the water column at a variety of depths. A minimum of three (3) surveys were completed each year in conjunction with visual encounter surveys (described below) between April and July, apart from the survey year 2022 when only two dip net surveys were completed during the month of July. This was consequent of a constrained time frame for the study in 2022. Any species observed was recorded on GEI Field Observation Report forms.

1.3 Cover Boards

During the 2019 survey season, 30 cover boards were placed throughout the restoration area (Figure 1) to provide temporary cover for various reptile and amphibian species and make visual encounters more likely. To attract a greater diversity of herpetofauna, both wood and corrugated metal cover objects were used (10 metal and 20 wood boards).

These cover boards were checked during each site visit over the three (3) survey years, 2019, 2021, and 2022. It should be noted that during the 2022 survey season, several cover boards were removed, broken, or impacted by construction. The remaining coverboards (19) were still checked for each site visit during the 2022 survey season. All species identified during these surveys were recorded.

1.4 Visual Encounter Surveys

Visual encounter surveys were conducted using random meanders within the preserve. A focus was placed on observing any ground movement, turning over logs and rocks, and searching through leaf litter and other debris. Three (3) visual encounter surveys of the restoration areas were conducted for all three (3) survey seasons, 2019, 2021, and 2022.

2. Results

The total species observed for 2019, 2021, and 2022 for each survey date are outlined in Tables 1, 2, and 3. Comparative results from all three (3) survey seasons, 2019, 2021, and 2022 can be found in Table 4.

2.1 Acoustic Surveys

2.1.1 2019

The first acoustic survey was completed on May 1, 2019. Due to melting snow from a recent snowfall, precipitation was considered damp/hazy during the survey, cloud cover was estimated at 100%, and air temperature was 5.6C (42°F). Spring peepers (*Pseudacris crucifer*) were heard during surveys at both Station A and Station B. At Station A, two (2) Spring Peepers were recorded outside the defined 100-meter area while at Station B, a single Spring Peeper was heard within the defined 100-meter area and an overlapping chorus of Spring Peeper calls were recorded outside of the defined 100-meter area.

The second acoustic survey was completed on May 21, 2019. Cloud cover during the survey was estimated at 100% and air temperature was 15.6C (60°F). During the acoustic survey, a single Bullfrog (*Rana (Lithobates) catsebiana*) was recorded at Station A within the defined 100-meter area.

The third and final acoustic survey was completed on June 13, 2019. At the time of the survey, skies were clear, and the air temperature was 16.7C (62°F). During the acoustic survey, a single Green Frog (*Rana (Lithobates) clamitans*) was recorded at Station A within the defined 100-meter area.

2.1.2 2021

The first acoustic survey of 2021 was completed on April 28, 2021. During the time of survey, there was no precipitation, cloud cover was estimated at 80%, and air temperature was 11.1C (52°F). A single (1) Spring Peeper and (1) Eastern American Toad (*Bufo americanus*) were heard during surveys at the western monitoring station, although they were outside the 100-meter area. No individuals were heard calling at the eastern monitoring station.

The second acoustic survey was completed on May 19, 2021. There was no precipitation during this survey, cloud cover during the survey was estimated at 40%, and air temperature was 18.3C (65°F). During the acoustic survey, one (1) Green Frog was heard calling from outside the 100-meter area at the western monitoring station. At the eastern station, five (5) Green Frogs were heard calling within the defined radius.

The third and final acoustic survey was completed on June 17, 2021. At the time of the survey, there was 100% cloud cover, no precipitation, and the air temperature recorded 26.1C (79°F). During the acoustic survey, two (2) Green Frogs were detected at the western monitoring station, one (1) outside and one (1) inside the 100-meter area.

2.1.3 2022

The only acoustic survey of 2022 was completed on July 6, 2021. During the time of survey, there was 70% cloud cover with no precipitation, and the air temperature was recorded at 22.2C (72°F). At the eastern station, seven (7) Green Frogs were heard calling inside of the 100-meter radius while two (2) Green Frogs were heard calling outside of the 100-meter radius. There was only one (1) Gray Tree Frog (*Hyla versicolor*) call picked up, however it was calling over 150-meters away. At the western monitoring station, there were six (6) Green Frogs detected calling within the 100-meter barrier and one (1) Green Frog outside the barrier.

2.2 Dip Net Surveys

2.2.1 2019

Dip net surveys were conducted on April 15, May 21, and June 31, 2019. Nothing was found during the June 31, 2019 survey. A Painted Turtle (*Chrysemys picta*) was found during April 15 survey and during the May 21, 2019, survey, multiple Green Frogs and a single Bullfrog tadpole were recorded.

2.2.2 2021

Dip net surveys were conducted on May 19 and June 17, 2021. During the May 19 survey, 17 Green Frogs of varying life stages were observed between the two (2) monitoring stations. During the June 17 survey, a total of seven (7) Green Frogs and one (1) Northern Leopard Frog (*Rana (Lithobates) pipiens*) were detected.

2.2.3 2022

Dip net surveys were conducted on July 5 and July 6, 2022. On July 5, technicians visited the site during the evening (20:30 – 21:15) to observe nocturnal herpetofauna movement. During the morning survey, one (1) Green Frog tadpole was found in the south wetland (pond), and a total of eight (8) Green Froglets were found in the central vernal pools.

The July 6 dip net survey occurred midafternoon. Seventeen (17) unidentifiable tadpoles and one (1) Green Frog tadpole were located within the south wetland (pond). There were only two (2) unidentifiable tadpoles discovered within the north wetland (pond).

2.3 Cover Boards

2.3.1 2019

Cover boards surveys were completed on April 30, May 21, and June 31, 2019. To observe nocturnal movement, the May 21 survey was conducted during the nighttime hours after the acoustic monitoring survey was completed.

No herpetofauna were found during the cover boards surveys over the April 30 or June 31, 2019, surveys. However, during the May 21, 2019, cover board survey, an (1) Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) was located under board #23 (corrugated metal) and a (1) Dekay's Brown Snake (*Storeria dekayi*) was found under cover board #22 (wooden).

2.3.2 2021

Cover boards surveys were completed on May 19 and June 17, 2021. On May 19, a single (1) Eastern Garter Snake was detected under cover board #7 (wooden). However, during the June 17



cover board survey, no herpetofauna were observed using the artificial cover objects.

2.3.3 2022

Cover boards surveys were completed on July 5 and July 6, 2022. During the July 5, cover boards survey, one (1) Eastern Garter Snake (Image 2.3.4) was found under cover board #20 (wooden). However, on the July 6 cover boards survey, no herpetofauna were observed using the artificial cover objects.

Image 2.3.4 An Eastern Garter Snake found under cover board #20 (wooden) near the north wetland (pond).

2.4 Visual Encounter Survey

2.4.1 2019

Visual encounter surveys were completed concurrently with the cover board surveys (April 15, May 21, and June 31, 2019). Two (2) Eastern Garter Snakes were located near a shed on the site during the April 30, 2019 survey. No herpetofauna were encountered during either the May 21 or June 31 visual encounter surveys.

2.4.2 2021

During 2021, visual encounter surveys were also completed concurrently with the cover board and dip net surveys (April 28, May 19, and June 17, 2021). No herpetofauna were observed during the April 28, 2021 survey. During the May 19, 2021 survey, 17 Green Frogs were encountered. Seven (7) Green Frogs and one (1) Northern Leopard Frog was observed during the June 17, 2021 survey.

2.4.3 2022

Visual encounters were completed on July 5, July 6, and July 7, 2022. July 5 and 6 visual encounters were completed concurrently with cover board surveys.

During the July 5 visual encounter, surveyors visited the site two times, one survey in the afternoon (12:00 – 17:00) and once in the evening (20:30 – 22:00). During the afternoon survey, they observed two (2) Northern Water Snakes (*Nerodia sipedon*), thirty-one (31) Northern Map Turtles (*Graptemys geographic*), ten (10) Painted Turtles, three (3) Green Frogs, one (1) Eastern Garter Snake, and one (1) Eastern American Toad. In the evening survey, they visually encountered seven (7) Green Frogs. Herpetofauna in the July 5 survey were observed either swimming along the shoreline, hiding in vegetation, or basking on logs/branches. Occurrences were mapped and locations are shown in Figure 2.

There was increase in diversity of herpetofauna species for the July 6 visual encounter. Surveyors recorded nineteen (19) Northern Map Turtles, eleven (11) Painted Turtles, one (1) Snapping Turtle, five (5) Green Frogs, one (1) American Toad, and two (2) Eastern Garter Snakes. While surveyors were meandering, they observed herpetofauna on parking lot log piles, small snapped-trees, and found several rumble mounds being used for turtle nesting sites, but there were no signs of snake use of the rubble mounds on site.

Lastly, during the July 7 survey, surveyors visually encountered five (5) Northern Water Snakes, eighteen (18) Northern Map Turtles, twelve (12) Painted Turtles, and one (1) Green Frog.



Image 2.4.4 Northern Water Snakes can be seen utilizing dead cattails along the Wilder River Trail as basking sites for thermoregulation.



Image 2.4.5 Buttonbush throughout the Muskegon Lake Nature Preserve make excellent basking sites while providing protection from potential predators, making them a critical microhabitat feature.



Image 2.4.6 Logs found in wetland areas around the nature preserve provide essential basking sites for northern map turtles like these and other turtle species to aid in maintaining an ideal body temperature.

3. Discussion

Between 2019 and 2021 the species diversity of the restoration site stayed relatively the same; however, the 2022 survey showed a significant increase in species diversity compared to previous survey years (Table 4). In addition, we found that the total relative abundance almost tripled in 2022 compared to the cumulative years (Table 4).

Post-restoration surveys saw a significant increase in common prey species such as Green Frogs and Eastern American Toads. Increasing populations of commonly abundant prey species will encourage more ecologically sensitive species to establish, by providing a food source.

In 2021, one (1) Northern Leopard Frog was observed, which is a species that was not documented pre-restoration. The Northern Leopard Frog was recently removed from the list of Species of Greatest Conservation Need in the Michigan Wildlife Action Plan published by the Michigan Department of Natural Resources (MDNR). While this means Leopard Frogs are not protected in Michigan, creating suitable habitat for this species is essential to the continued recovery of this population.

We saw a substantial increase in omnivorous herpetofauna during the post-restoration surveys, encountering species such as Snapping Turtles, Eastern Garter Snakes, Painted Turtles, and Map Turtles (Table 3). Aside from feeding on prey sources such as Anurans, these omnivores play an important role of transferring energy flow within and between ecosystems while maintaining balance in the local food web (Glorioso et al., 2010; Reading et al., 2010). As reptiles are facing a present global decline, assessing, restoring, and maintaining suitable habitats for these species becomes especially important to prevent imminent extirpation.

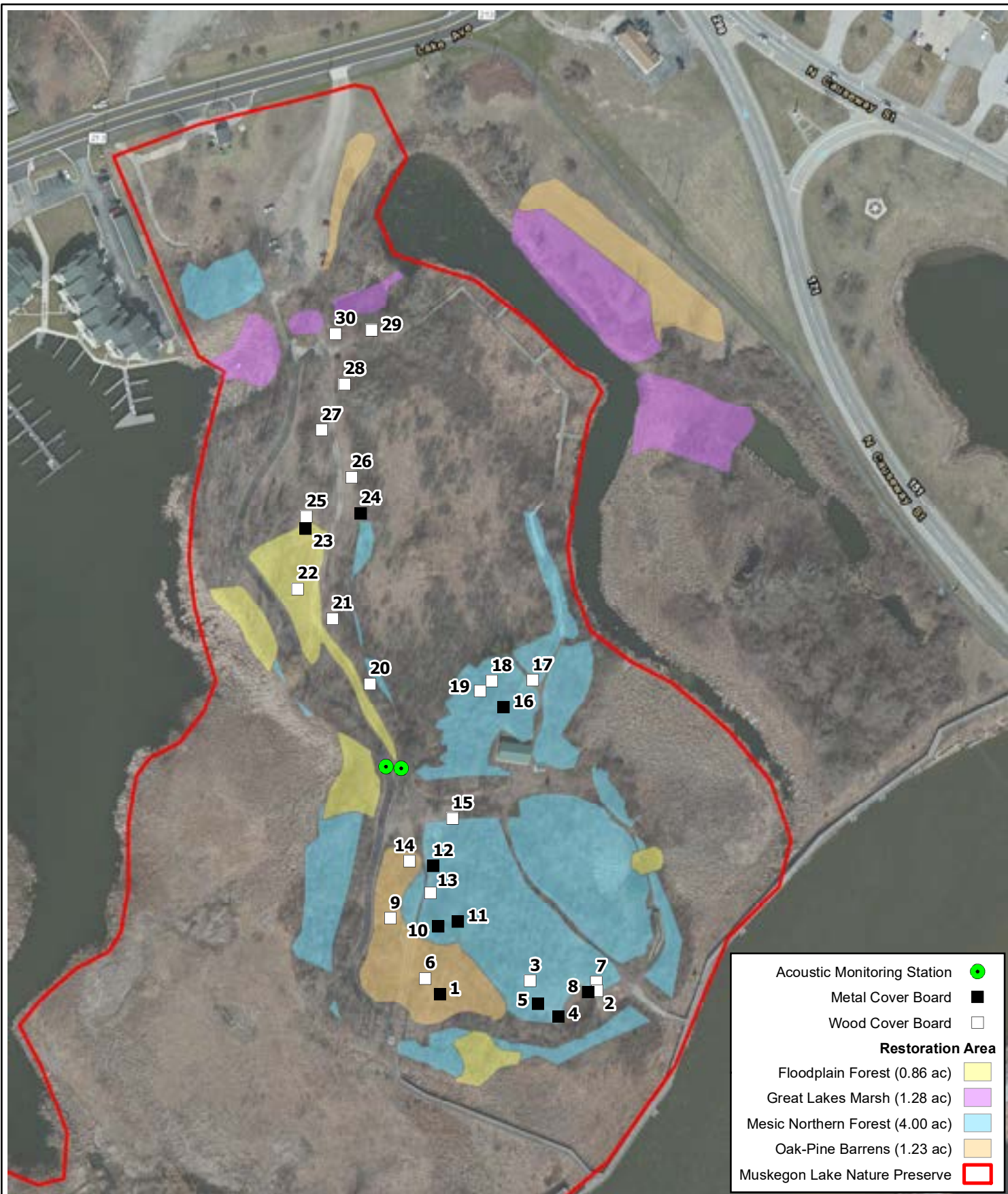
To continue protecting the herpetofauna at MLNP, the species need proper access to habitats used for breeding, feeding, nesting, and overwintering. We recommend continuing future post-restoration monitoring to ensure that the herpetofauna diversity and abundance increases and stabilizes over time. We suggest using acoustic, visual, and additional trap arrays to maximize detection probability over a shorter sampling time span. Pursuing other monitoring, such as ecosystem monitoring can additionally help provide information on the quality of the herpetofauna's habitats.

In summary, based on the current improvements shown among the survey years 2019, 2021, and 2022, GEI expects the MLNP's herpetofauna populations to continue to grow in diversity and abundance as individuals rediscover and translocate to the newly restored area. Further adaptive management of the site that integrates information from these surveys and others can help continue restoration efforts of herps at MLNP and the ecosystems they inhabit. It is with hope that these proactive measures can fully restore the site and help maintain trophic balance and promote a healthy ecosystem.

4. References

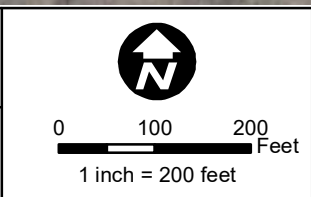
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Figures



Muskegon Lake Nature Preserve
Muskegon County, Michigan

West Michigan Shoreline
Regional Development Commission



COVER BOARD LOCATIONS

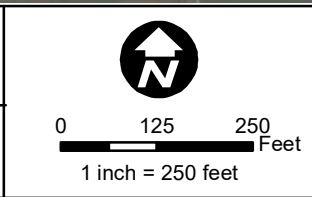
Project: 1901441 Figure: 1



Restoration Area		
Floodplain Forest (0.86 ac)	American Toad	Northern Water Snake
Great Lakes Marsh (1.28 ac)	Blanding's Turtle	Painted Turtle
Mesic Northern Forest (4.00 ac)	Eastern Garter Snake	Tadpoles (unidentified)
Oak-Pine Barrens (1.23 ac)	Green Frog	Snapping turtle
Muskegon Lake Nature Preserve	Map Turtle	Turtle Nest
	Milk Snake	Bullfrog tadpole

Muskegon Lake Nature Preserve
Muskegon County, Michigan

West Michigan Shoreline
Regional Development Commission



2022 VISUAL SURVEY

Project: 1901441 Figure: 2

Tables

Table 1. Total number of herpetofauna observed during each survey date in 2019.

2019 Herpetofauna Abundance

	April 15	April 30	May 1	May 21	June 13	June 31	Total
Green Frog	-	-	2	-	1	-	3
Spring Peeper	-	-	3	-	-	-	3
Bullfrog	-	-	1	1	-	-	2
Eastern Garter Snake	-	2	-	1	-	-	3
DeKay's Brown Snake	-	-	-	1	-	-	1
Painted Turtle	1	-	-	-	-	-	1
Total	1	2	6	3	1	0	13

Table 2. Total number of herpetofauna observed during each survey date in 2021.

2021 Herpetofauna Abundance

	April 28	May 19	June 17	Total
Eastern American Toad	1	-	-	1
Spring Peeper	1	-	-	1
Green Frog	-	23	9	32
Northern Leopard Frog	-	-	1	1
Eastern Garter Snake	-	1	-	1
Total	2	24	10	36

Table 3. Total number of herpetofauna observed during each survey date in 2022.

2022 Herpetofauna Abundance

	July 5	July 6	July 7	Total
Eastern American Toad	1	1	-	2
Northern Water Snake	2	-	5	7
Green Frog	19	19	1	39
Northern Map Turtle	31	19	18	68
Eastern Garter Snake	2	2	-	4
Painted Turtle	10	11	12	33
Snapping Turtle	-	1	-	1
Total	65	52	36	154

Table 4. Total number of herpetofauna observed across the years 2019, 2021, and 2022 representing pre and post restoration relative abundance.

Herpetofauna Abundance Pre and Post Restoration

	2019*	2021	2022	Total
Eastern American Toad	-	1	2	3
Spring Peeper	7	1	-	8
Green Frog	5	32	39	76
Northern Leopard Frog	-	1	-	1
Bullfrog	2	-	-	2
Eastern Garter Snake	3	1	4	8
DeKay's Brown Snake	2	-	-	2
Painted Turtle	1	-	33	34
Northern Water Snake	-	-	7	7
Northern Map Turtle	-	-	68	68
Snapping Turtle	-	-	1	1
Total	20	36	154	210

MUSKEGON LAKE NATURE PRESERVE MERES FISH AND WILDLIFE HABITAT RESTORATION PROJECT

100% CONSTRUCTION DOCUMENTS
March 9, 2020

PREPARED FOR:

WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION
316 MORRIS AVENUE, SUITE 340
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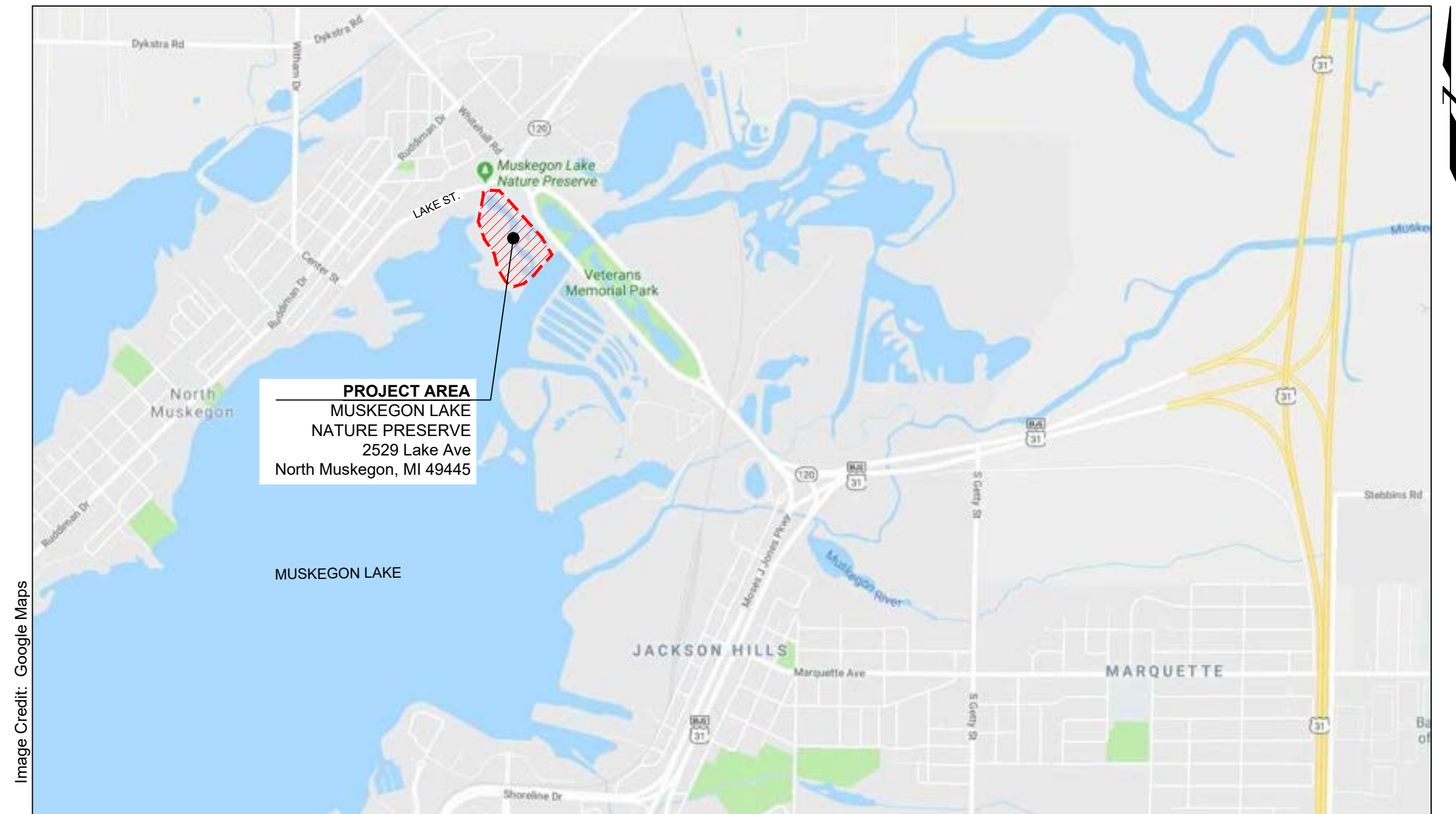


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PROJECT PARTNERS:



LOCATION MAP
NOT TO SCALE



PROJECT AREA
NOT TO SCALE



Muskegon County

MICHIGAN STATE MAP

NOT TO SCALE

Sheet List Table

Sheet Number	Sheet Title
G1	COVER SHEET
C1	EXISTING CONDITIONS
C2	ACCESS & STAGING
C3	INVASIVE SPECIES REMOVAL PLAN
C4	PROPOSED CONDITIONS
C5	DEBRIS REMOVAL PLAN
C6	WORK AREAS 1, 2, & 3
C7	RESTORATION AREAS 1, 2, & 3
C8	WORK AREAS 4, 5, & 6
C9	RESTORATION AREAS 4, 5, & 6
C10	WORK AREAS 7 & 8
C11	RESTORATION AREAS 7 & 8
D1	DETAILS
D2	PLANT LISTS

NO.	DATE	ISSUE/REVISION	APP
5	3/9/20	100 % CONSTRUCTION DOCUMENTS - 3	WL
4	1/27/20	100 % CONSTRUCTION DOCUMENTS - 2	WL
3	12/12/19	100 % CONSTRUCTION DOCUMENTS	WL
2	10/10/19	90 % CONSTRUCTION DOCUMENTS	WL
1	8/5/19	PRELIMINARY CONCEPTS	WL
NO.	DATE	ISSUE/REVISION	APP

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	Checked:	- BM
	Drawn:	- WL
	Submitted By:	- BM
	P.E. Number:	- 44371
	Submittal Date:	- 3/9/20

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Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project
COVER SHEET

DWG. NO. **G1**
ISSUE **3**



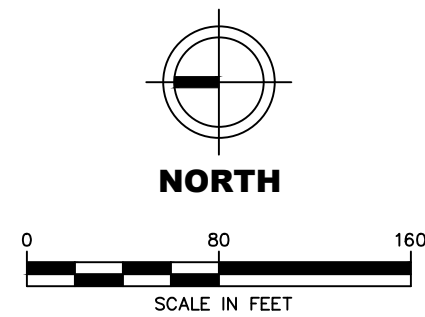
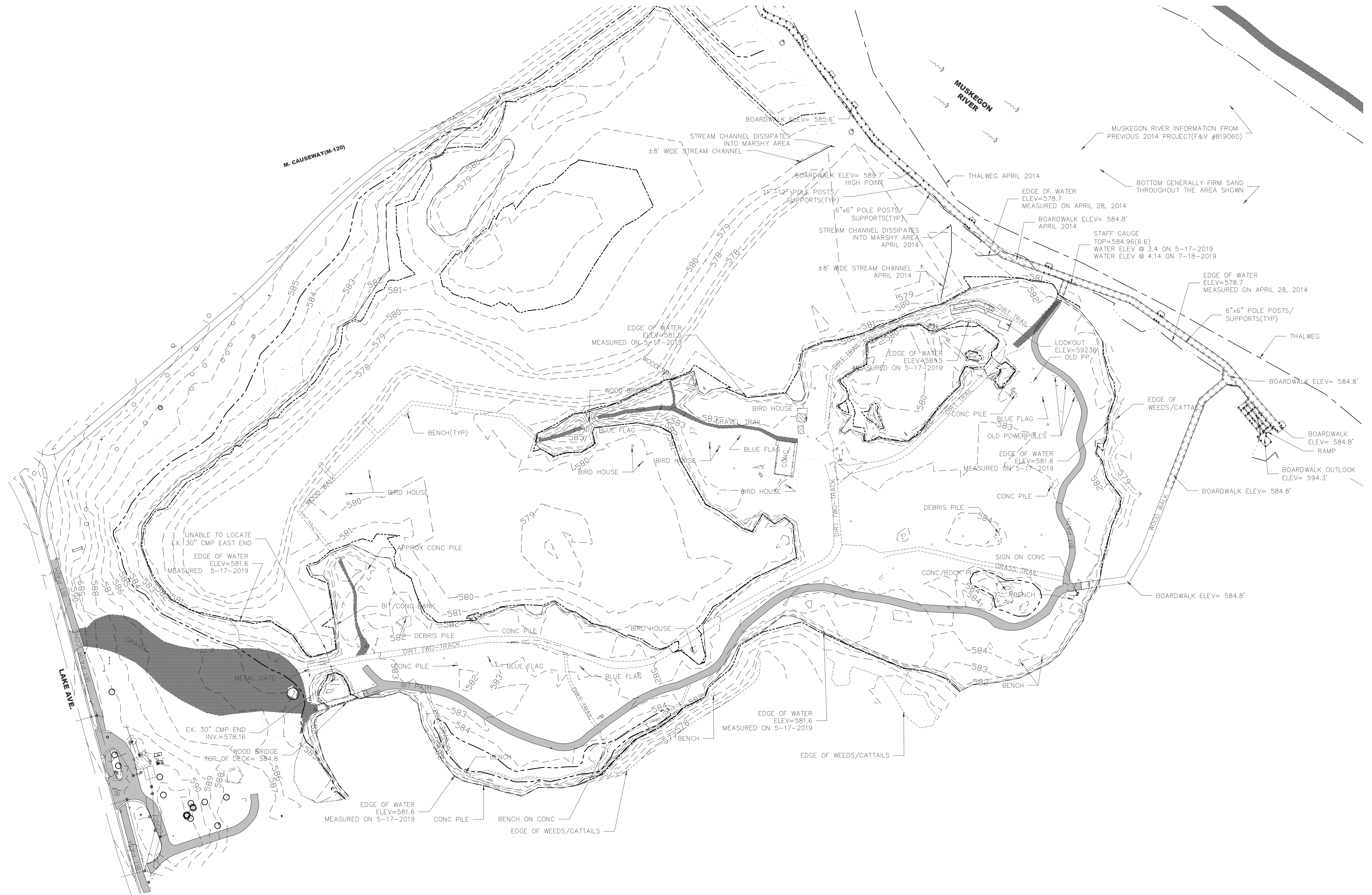
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EXISTING FEATURES LEGEND

- EX. WATER ELEV.
- EX. WATER ELEV. (MUSKEGON RIVER)
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YR FLOOD ELEV.
- MUSKEGON RIVER THALWEG
- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- WETLANDS
- CONCRETE / ASPHALT
- GRAVEL
- BENCHMARK

NOTES

- 1) Benchmark #4A elevation 592.97'. Location at southwest corner of 'Community Events' sign on Lake Ave, east of entrance to the nature preserve. NAVD88 Via VRS, OPUS & GPS OBSV.
- 2) Water elevation measured on 5/17/19 and 4/28/14. Water elevation varies depending on location.
- 3) OHWM elevation is 581.5'.
- 4) 100-YR Floodplain Elevation is 584.4'.
- 5) Muskegon River information from previous 2014 Project (F&V #819060).



Attention:	NO.	DATE	ISSUE/REVISION	APP
	5	3/9/20	100 % CONSTRUCTION DOCUMENTS - 3	WL
	4	1/27/20	100 % CONSTRUCTION DOCUMENTS - 2	WL
	3	12/12/19	100 % CONSTRUCTION DOCUMENTS	WL
	2	10/10/19	90 % CONSTRUCTION DOCUMENTS	WL
	1	8/5/19	PRELIMINARY CONCEPTS	WL
	NO.	DATE	ISSUE/REVISION	APP

	Designed:	- BM
	Checked:	- BM
	Drawn:	- WL
	Submitted By:	- BM
	P.E. Number:	- 44371
	Submittal Date:	- 3/9/20

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Muskegon Lake Nature Preserve
 MERES Fish and Wildlife Habitat
 Restoration Project
 EXISTING CONDITIONS

DWG. NO.
C1
 ISSUE
3

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EXISTING FEATURES LEGEND

- EX. WATER ELEV.
- EX. WATER ELEV. (MUSKEGON RIVER)
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YR. FLOOD ELEV.
- MUSKEGON RIVER THALWEG
- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- WETLANDS
- CONCRETE / ASPHALT
- GRAVEL
- BENCHMARK

ACCESS/STAGING LEGEND

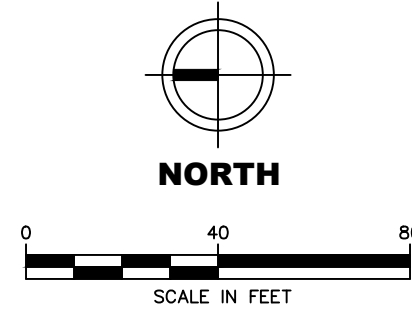
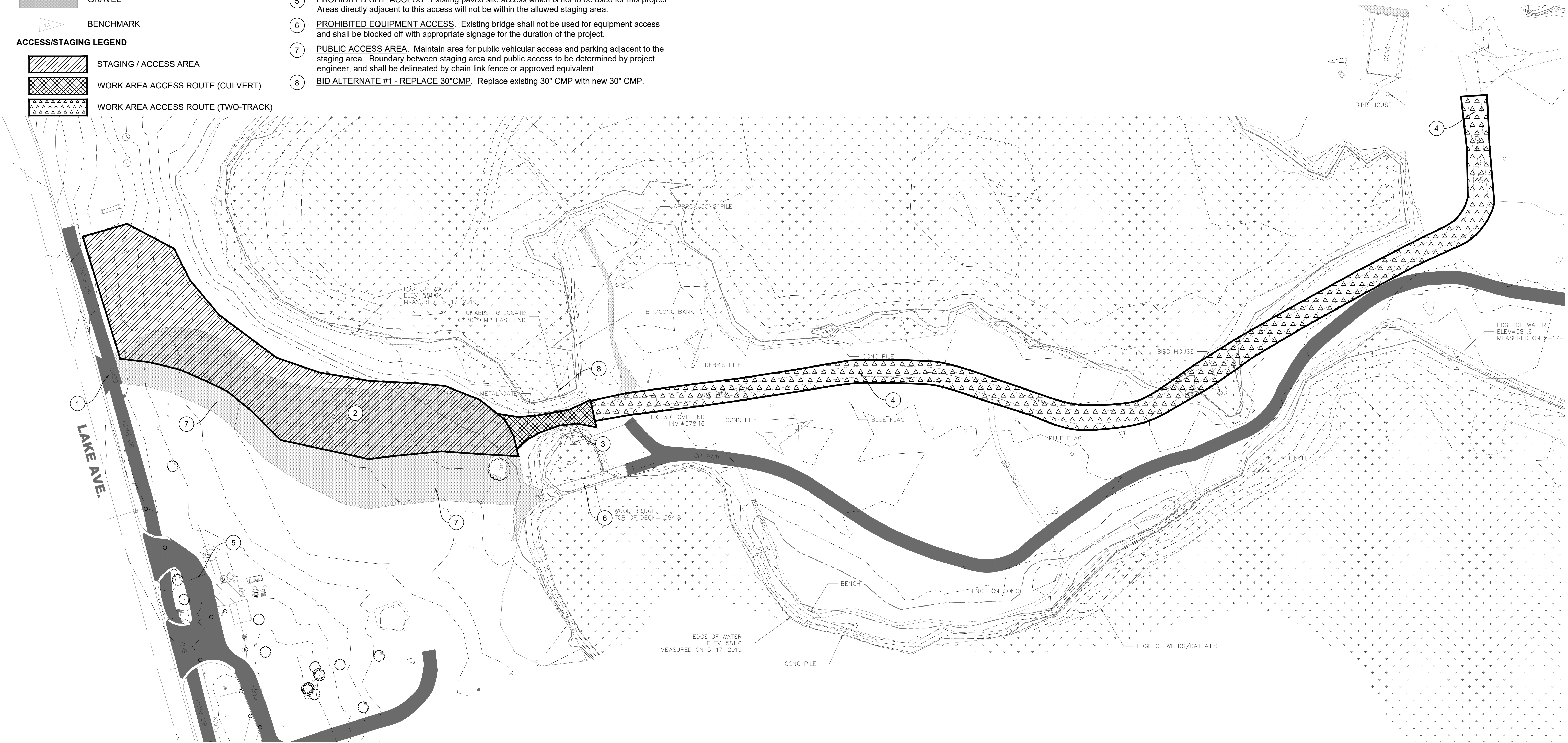
- STAGING / ACCESS AREA
- WORK AREA ACCESS ROUTE (CULVERT)
- WORK AREA ACCESS ROUTE (TWO-TRACK)

STAGING & ACCESS KEY

- 1 SITE ACCESS. Primary site access from Lake Ave.
- 2 STAGING AREA. Existing gravel drive and parking area to serve as primary access and staging area for this project. Maintain a minimum 15' buffer from existing wetlands, natural areas, and water bodies. Exact staging limits to be located in the field by the project engineer. Chain link fence shall be installed at the perimeter of the staging area adjacent to public right-of-way and public/private use areas.
- 3 WORK AREA ACCESS. Utilize existing dirt two-track road to access the work area for this project. Contractor to coordinate with the project engineer to confirm proposed construction equipment is appropriately sized relative to the size of the access route. The Contractor may be required to stabilize and support the access road in the area above the existing culvert to ensure the structural integrity of this area.
- 4 PRIMARY ACCESS ROUTE. Existing two-track path, improve route as necessary.
- 5 PROHIBITED SITE ACCESS. Existing paved site access which is not to be used for this project. Areas directly adjacent to this access will not be within the allowed staging area.
- 6 PROHIBITED EQUIPMENT ACCESS. Existing bridge shall not be used for equipment access and shall be blocked off with appropriate signage for the duration of the project.
- 7 PUBLIC ACCESS AREA. Maintain area for public vehicular access and parking adjacent to the staging area. Boundary between staging area and public access to be determined by project engineer, and shall be delineated by chain link fence or approved equivalent.
- 8 BID ALTERNATE #1 - REPLACE 30"CMP. Replace existing 30" CMP with new 30" CMP.

NOTES

- 1) Benchmark #4A elevation 592.97'. Location at southwest corner of 'Community Events' sign on Lake Ave, east of entrance to the nature preserve. NAVD88 Via VRS, OPUS & GPS OBSV.
- 2) Water elevation measured on 5/17/19 and 4/28/14. Water elevation varies depending on location.
- 3) OHWM elevation is 581.5'.
- 4) 100-YR Floodplain Elevation is 584.4'.
- 5) Muskegon River information from previous 2014 Project (F&V)



NO.	DATE	ISSUE/REVISION	APP
5	3/9/20	100 % CONSTRUCTION DOCUMENTS - 3	WL
4	1/27/20	100 % CONSTRUCTION DOCUMENTS - 2	WL
3	12/12/19	100 % CONSTRUCTION DOCUMENTS	WL
2	10/10/19	90 % CONSTRUCTION DOCUMENTS	WL
1	8/5/19	PRELIMINARY CONCEPTS	WL

Designed:	- BM
Checked:	- BM
Drawn:	- WL
Submitted By:	- BM
P.E. Number:	- 44371
Submittal Date:	- 3/9/20

GEI Consultants
5525 Edgewater Drive
Allendale, MI 49401

WMSRDC
WEST MICHIGAN SHORELINE
REGIONAL DEVELOPMENT COMMISSION
316 Morris Avenue, Suite 340
Muskegon, MI 49440

Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project
ACCESS & STAGING

DWG. NO. **C2**
ISSUE **3**

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EXISTING FEATURES LEGEND

- EX. WATER ELEV.
- EX. WATER ELEV. (MUSKEGON RIVER)
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YR FLOOD ELEV.
- MUSKEGON RIVER THALWEG
- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- WETLANDS
- CONCRETE / ASPHALT
- GRAVEL
- BENCHMARK

NOTES

- 1) Benchmark #4A elevation 592.97'. Location at southwest corner of 'Community Events' sign on Lake Ave, east of entrance to the nature preserve. NAVD88 Via VRS, OPUS & GPS OBSV.
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- 3) OHWM elevation is 581.5'.
- 4) 100-YR Flood Elevation is 584.4'.
- 5) Muskegon River information from previous 2014 Project (F&V #819060).

INVASIVE SPECIES REMOVAL PHASING

- PHASE 1: Remove any woody invasive species within proposed construction areas and directly adjacent to proposed construction areas, including previously treated area (AREA 'A'). Total Phase 1 treatment area is 6.2 acres.
- PHASE 2: Re-treatment of all Phase 1 areas (AREA 'A') and removal of all remaining invasive species within surveyed areas, including previously treated areas (AREA 'B'). Herbaceous treatments to occur in the 2020 growing season; Woody treatments to occur in fall/winter 2020/2021. Total Phase 2 treatment area is 10.3 acres.
- PHASE 3: Follow-up treatments to all treatment areas in growing season of 2021 (AREA 'A' & 'B').

*INVASIVE SPECIES REMOVAL NOTE: The invasive species removal acreage listed above corresponds with the invasive species areas within treatment areas 'A' and 'B', not the actual footprint of the treatment areas. The treatment areas are outlined to help the contractor identify the

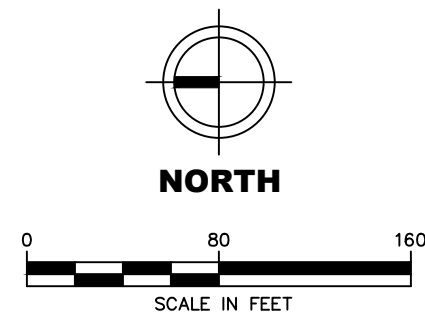
INVASIVE SPECIES REMOVAL LEGEND

- Bell's Honeysuckle (5.1 ac) - Untreated to Date
- Previously Treated Areas (2.8 ac)
- Proposed Construction Area Footprints to Treat (2.4 ac)
- Invasive Species Survey Point
- Invasive Species Survey Point Identification
- Area
- Density
- Species
- Point ID

Species Key

- Eu - Autumn Olive
- Lb - Bell's Honeysuckle
- A - Burdock
- Ap - Garlic Mustard
- Rj - Japanese Knotweed
- Lc - Motherwort
- Co - Oriental Bittersweet
- Vm - Periwinkle
- L - Privet
- Ls - Purple Loosestrife
- Cm - Spotted Knapweed

Density	Area
1 Sparse	Individual / Few / Several
2 Patchy	< 1,000 sqft
3 Dense	1,000 sqft to 0.5 acre
4 Monoculture	0.5 acre to 1 acre
5 -	> 1 acre



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1	8/5/19	PRELIMINARY CONCEPTS	WL

Attention:	5	3/9/20	100 % CONSTRUCTION DOCUMENTS - 3	WL
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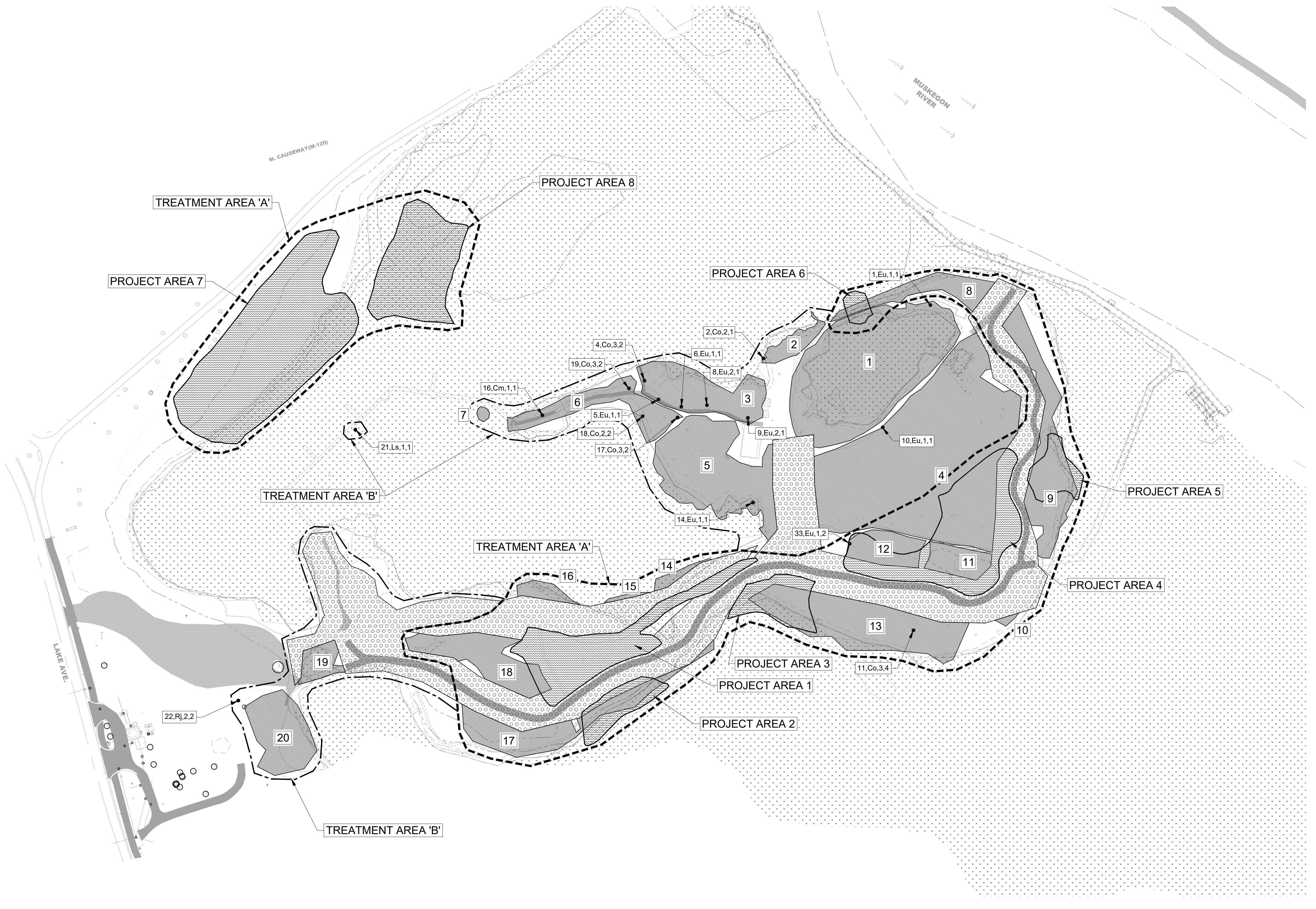
GEI Consultants
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 316 Morris Avenue, Suite 340
 Muskegon, MI 49440

Muskegon Lake Nature Preserve
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 Restoration Project

**INVASIVE SPECIES REMOVAL
 PLAN**

DWG. NO. **C3**
 ISSUE **3**



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OVERALL PROJECT EARTHWORK				
	VOL (CY)			
CUT	4,989			
FILL	1,487			
NET	3,487 CY CUT			
OVERALL PROJECT OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	902		34,032	
FILL	35		821	
NET	867 CUT		34,853	
OVERALL PROJECT 100-YR FLD. IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	4,690		80,750	
FILL	-562		-29,047	
NET	-4,494 CUT		-109,797	
OVERALL PROJECT WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	1,452		40,243	
FILL	-9		-308	
NET	-1,443 CUT		-40,551	

EXISTING FEATURES LEGEND

- EX. WATER ELEV.
- EX. WATER ELEV. (MUSKEGON RIVER)
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YR FLOOD ELEV.
- MUSKEGON RIVER THALWEG
- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR

PROPOSED FEATURES LEGEND

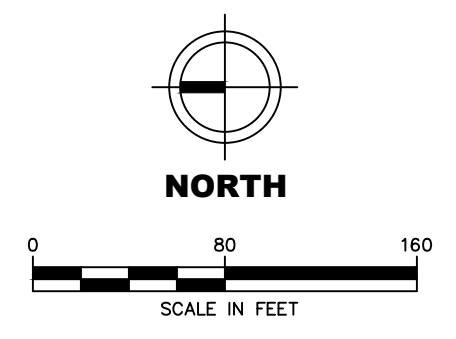
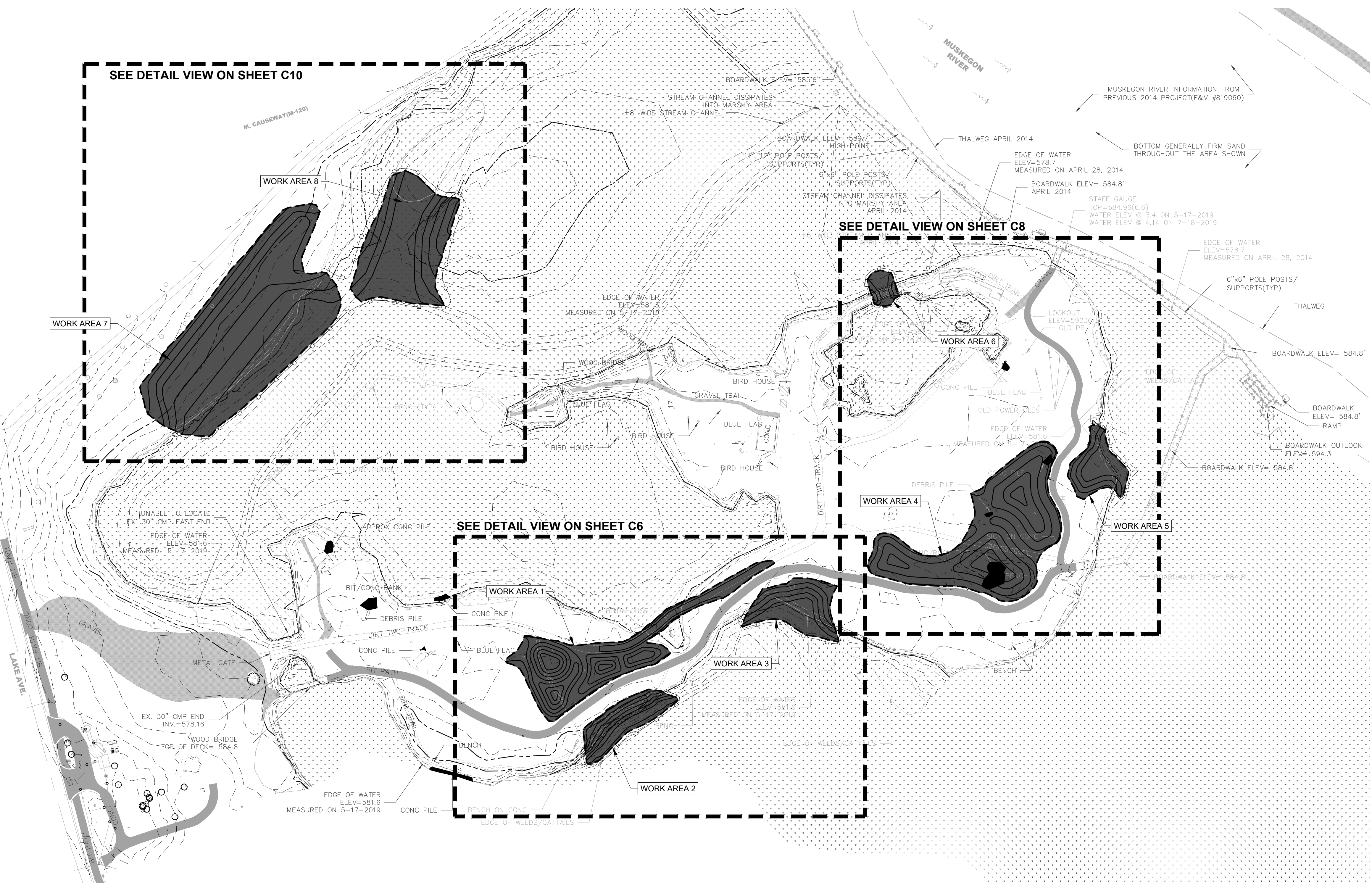
- GRADING LIMITS
- MAJOR CONTOUR
- MINOR CONTOUR
- PROJECT AREA FOOTPRINT
- CONCRETE / ASPHALT
- GRAVEL

- NOTES**
- Benchmark #4A elevation 592.97'. Location at southwest corner of 'Community Events' sign on Lake Ave, east of entrance to the nature preserve. NAVD88 Via VRS. OPUS & GPS OBSV.
 - Water elevation measured on 5/17/19 and 4/28/14. Water elevation varies depending on location.
 - OHWM elevation is 581.5'.
 - 100-YR Floodplain Elevation is 584.4'.
 - Muskegon River information from previous 2014 Project (F&V #819060).

Habitat Structures Table		
Project Area	# of Structures	Fill Vol. (CY)
1	5	3.3
2	3	2.0
3	4	2.6
4	5	3.3
5	4	2.6
6	7	4.6
7	7	4.6
8	7	4.6



AREA 1 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	848		12,500	
FILL	118		5,045	
NET	730 CUT		17,545	
AREA 1 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	0		0	
FILL	35		821	
NET	35 FILL		821	
AREA 1 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	848		12,500	
FILL	118		5,045	
NET	730 CUT		17,545	
AREA 1 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	0		0	
FILL	9		308	
NET	9 FILL		308	
AREA 2 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	288		5,918	
FILL	0		0	
NET	288 CUT		5,918	
AREA 2 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	71		2,991	
FILL	0		0	
NET	71 CUT		2,991	
AREA 2 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	255		4,698	
FILL	0		0	
NET	255 CUT		4,698	
AREA 2 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	83		3,017	
FILL	0		0	
NET	83 CUT		3,017	
AREA 3 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	258		7,339	
FILL	0		0	
NET	258 CUT		7,339	
AREA 3 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	57		2,642	
FILL	0		0	
NET	57 CUT		2,642	
AREA 3 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	258		7,339	
FILL	0		0	
NET	258 CUT		7,339	
AREA 3 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	75		3,273	
FILL	0		0	
NET	75 CUT		3,273	
AREA 4 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	1		125	
FILL	1,369		27,885	
NET	1,368 FILL		28,010	
AREA 4 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	0		0	
FILL	0		0	
NET	-		-	
AREA 4 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	1		125	
FILL	444		24,002	
NET	444 FILL		24,127	
AREA 4 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	0		0	
FILL	0		0	
NET	-		-	
AREA 5 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	235		5,050	
FILL	0		0	
NET	235 CUT		5,050	
AREA 5 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	28		1,360	
FILL	0		0	
NET	28 CUT		1,360	
AREA 5 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	235		5,050	
FILL	0		0	
NET	235 CUT		5,050	
AREA 5 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	53		1,843	
FILL	0		0	
NET	53 CUT		1,843	
AREA 6 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	45		1,621	
FILL	0		0	
NET	45 CUT		1,621	
AREA 6 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	17		1,105	
FILL	0		0	
NET	17 CUT		1,105	
AREA 6 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	45		1,621	
FILL	0		0	
NET	45 CUT		1,621	
AREA 6 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	36		1,467	
FILL	0		0	
NET	36 CUT		1,467	
AREA 7 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	2,570		44,880	
FILL	0		0	
NET	2,570 CUT		44,880	
AREA 7 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	229		8,711	
FILL	0		0	
NET	229 CUT		8,711	
AREA 7 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	2,304		30,793	
FILL	0		0	
NET	2,304 CUT		30,793	
AREA 7 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	461		12,019	
FILL	0		0	
NET	461 CUT		12,019	
AREA 8 EARTHWORK				
	VOL (CY)		AREA (SF)	
CUT	744		18,624	
FILL	0		0	
NET	744 CUT		18,624	
AREA 8 OHWM IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	500		17,223	
FILL	0		0	
NET	500 CUT		17,223	
AREA 8 100-YR FLOOD IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	744		18,624	
FILL	0		0	
NET	744 CUT		18,624	
AREA 8 WETLAND IMPACTS				
	VOL (CY)		AREA (SF)	
CUT	744		18,624	
FILL	0		0	
NET	744 CUT		18,624	



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NO.	DATE	ISSUE/REVISION	APP

Designed:	- BM
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Submittal Date:	- 3/9/20

GEI Consultants
5225 Edgewater Drive
Allendale, MI 49401

WMSRDC
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316 Morris Avenue, Suite 340
Muskegon, MI 49440

Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project
PROPOSED CONDITIONS

DWG. NO. **C4**
ISSUE **3**

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EXISTING FEATURES LEGEND

- EX. WATER ELEV.
- EX. WATER ELEV. (MUSKEGON RIVER)
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YR FLOOD ELEV.
- MUSKEGON RIVER THALWEG
- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- ▨ WETLANDS
- ▨ CONCRETE / ASPHALT
- ▨ GRAVEL
- ▲ BENCHMARK

DEBRIS REMOVAL LEGEND

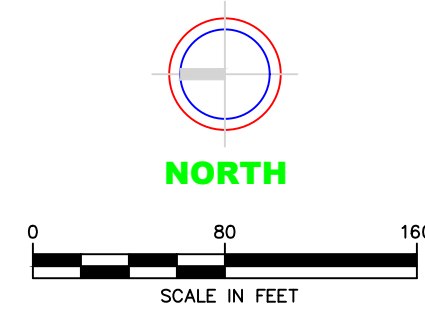
- ▨ SURVEYED DEBRIS PILE (9 TOTAL)

DEBRIS REMOVAL KEY

- ① CONCRETE / DEBRIS REMOVAL LOCATION. Remove and dispose of identified piles, place clean topsoil level with adjacent grades (or as indicated on proposed grading plans) and plant with floodplain forest seed mix (see sheet D2). Number adjacent to the key call out to indicate specific debris piles.

NOTES

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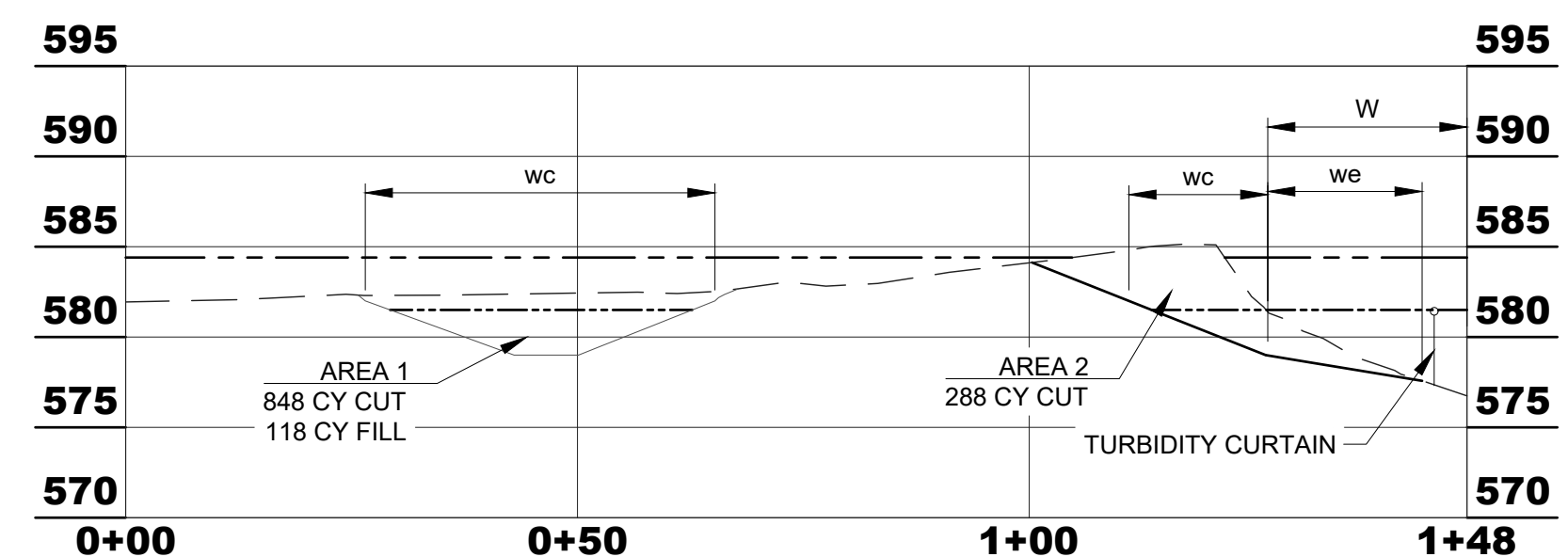
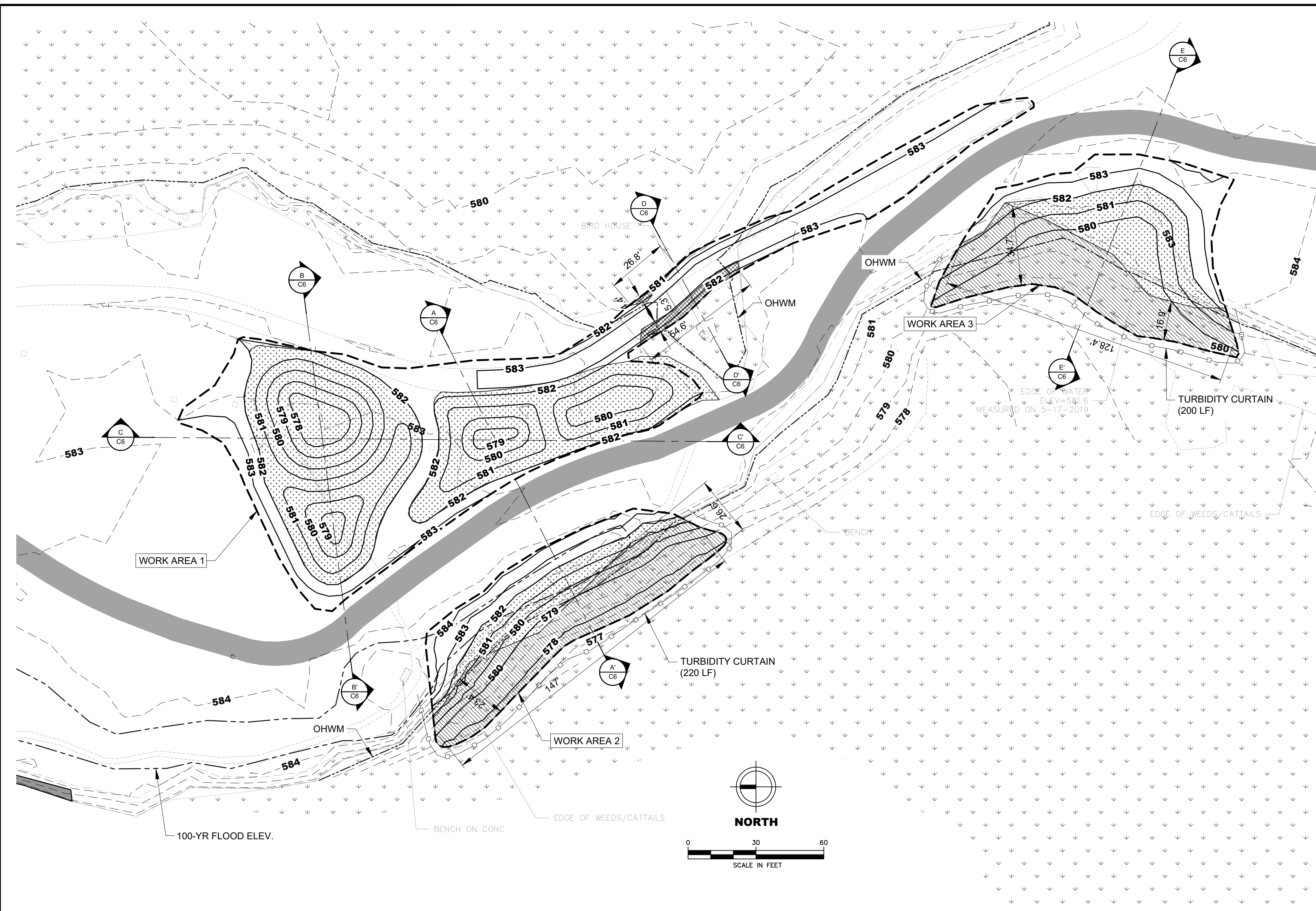
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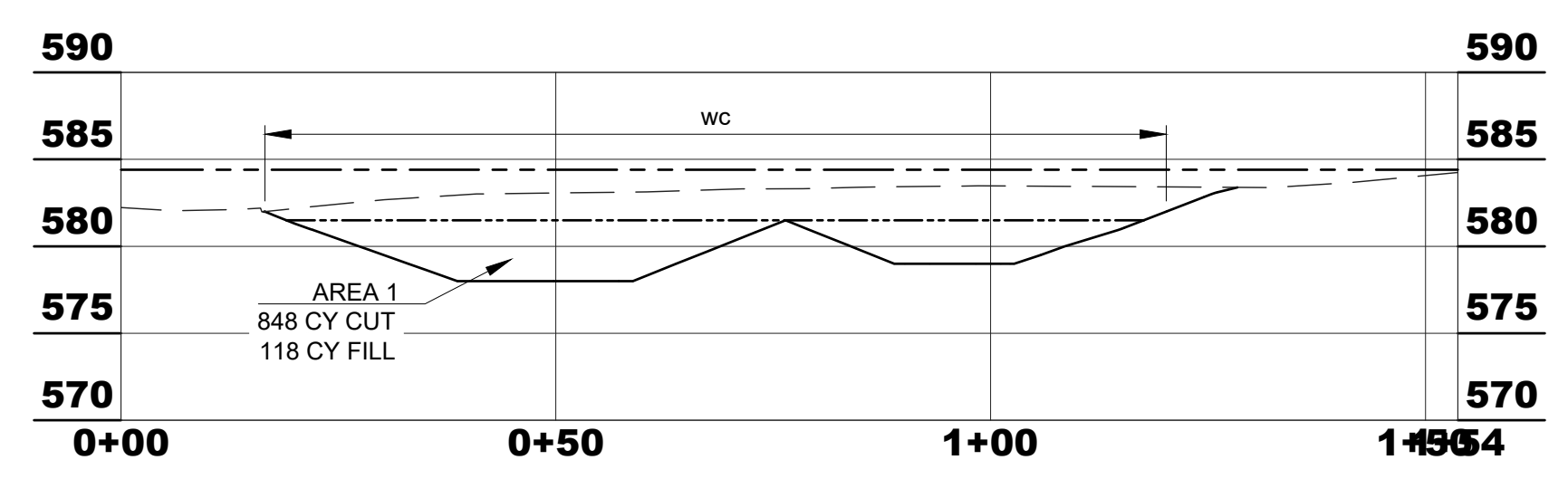
Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project
DEBRIS REMOVAL PLAN

DWG. NO.
C5
ISSUE
3

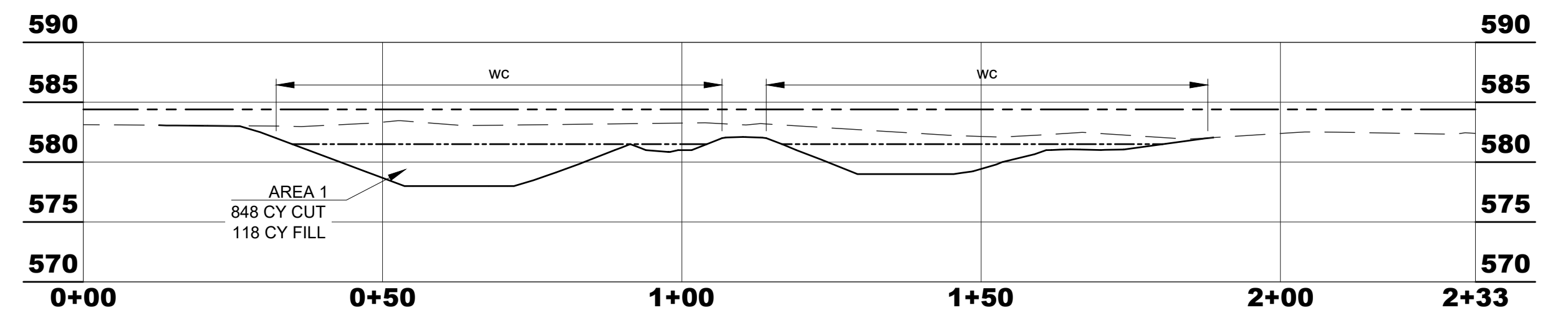
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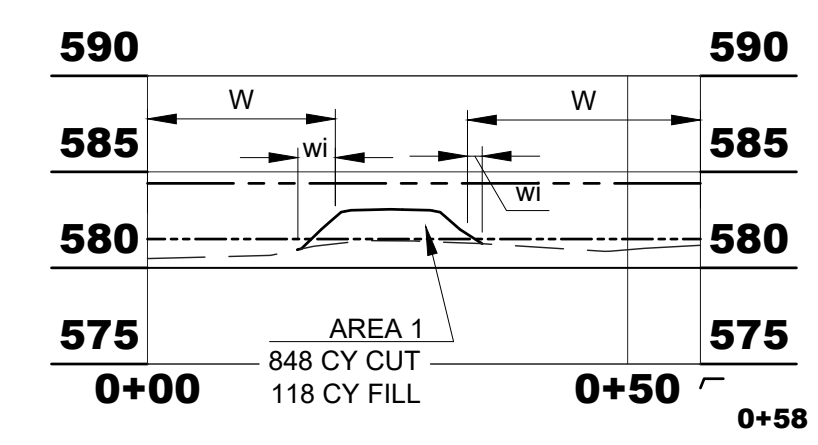
CROSS-SECTION A-A'
SCALE H: 1"=20' V: 1"=10'



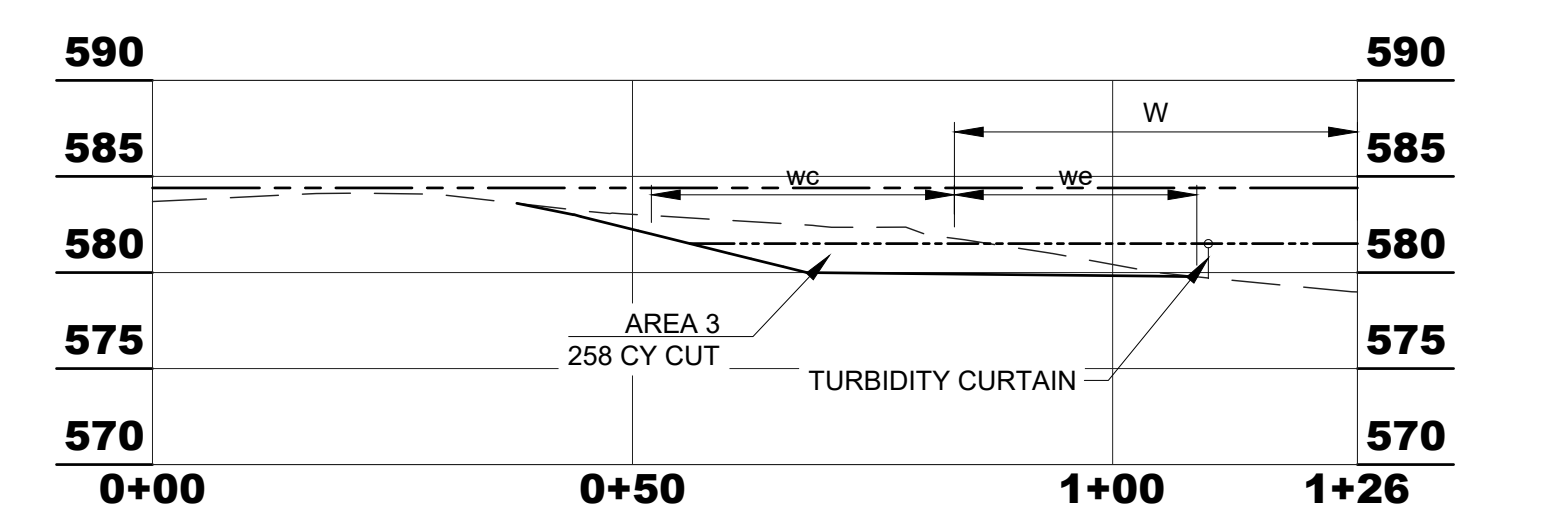
CROSS-SECTION B-B'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION C-C'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION D-D'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION E-E'
SCALE H: 1"=20' V: 1"=10'

EXISTING FEATURES LEGEND

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- EX. WATER ELEV. (MUSKEGON RIVER)
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- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- WETLANDS
- CONCRETE / ASPHALT
- GRAVEL
- BENCHMARK

PROPOSED FEATURES LEGEND

- GRADING LIMITS
- MAJOR CONTOUR
- MINOR CONTOUR
- TURBIDITY CURTAIN
- SECTION MARKER
- WETLAND IMPACT AREAS (FILL)
- WETLAND ENHANCEMENT AREAS (CUT)
- WETLAND CREATION AREAS (EXCAVATION IN UPLAND)
- DEBRIS PILE REMOVAL

NOTES

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- 4) 100-YR Floodplain Elevation is 584.4'.
- 5) Muskegon River information from previous 2014 Project (F&V #819060).
- 6) Exact location and installation of turbidity curtain to be approved by project engineer prior to excavation activities.

AREA 1 EARTHWORK

	VOL (CY)	AREA (SF)
CUT	848	12,500
FILL	118	5,045
NET	730 CUT	17,545

AREA 1 OHWM IMPACTS

	VOL (CY)	AREA (SF)
CUT	0	0
FILL	35	821
NET	35 FILL	821

AREA 1 100-YR FLOOD IMPACTS

	VOL (CY)	AREA (SF)
CUT	848	12,500
FILL	118	5,045
NET	730 CUT	17,545

AREA 1 WETLAND IMPACTS

	VOL (CY)	AREA (SF)
CUT	0	0
FILL	9	308
NET	9 FILL	308

*WETLAND CREATION: 9,826 SF (0.23 AC)

AREA 2 EARTHWORK

	VOL (CY)	AREA (SF)
CUT	288	5,918
FILL	0	-
NET	288 CUT	5,918

AREA 2 OHWM IMPACTS

	VOL (CY)	AREA (SF)
CUT	71	2,991
FILL	0	0
NET	71 CUT	2,991

AREA 2 100-YR FLOOD IMPACTS

	VOL (CY)	AREA (SF)
CUT	255	4,698
FILL	0	0
NET	255 CUT	4,698

AREA 2 WETLAND IMPACTS

	VOL (CY)	AREA (SF)
CUT	83	3,017
FILL	0	0
NET	83 CUT	3,017

*WETLAND CREATION: 1,310 SF (0.03 AC)

AREA 3 EARTHWORK

	VOL (CY)	AREA (SF)
CUT	258	7,339
FILL	0	-
NET	258 CUT	7,339

AREA 3 OHWM IMPACTS

	VOL (CY)	AREA (SF)
CUT	57	2,642
FILL	0	0
NET	57 CUT	2,642

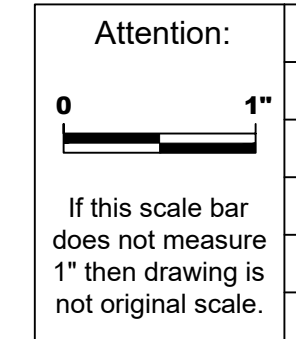
AREA 3 100-YR FLOOD IMPACTS

	VOL (CY)	AREA (SF)
CUT	258	7,339
FILL	0	-
NET	258 CUT	7,339

AREA 3 WETLAND IMPACTS

	VOL (CY)	AREA (SF)
CUT	75	3,273
FILL	0	0
NET	75 CUT	3,273

*WETLAND CREATION: 2,148 SF (0.05 AC)



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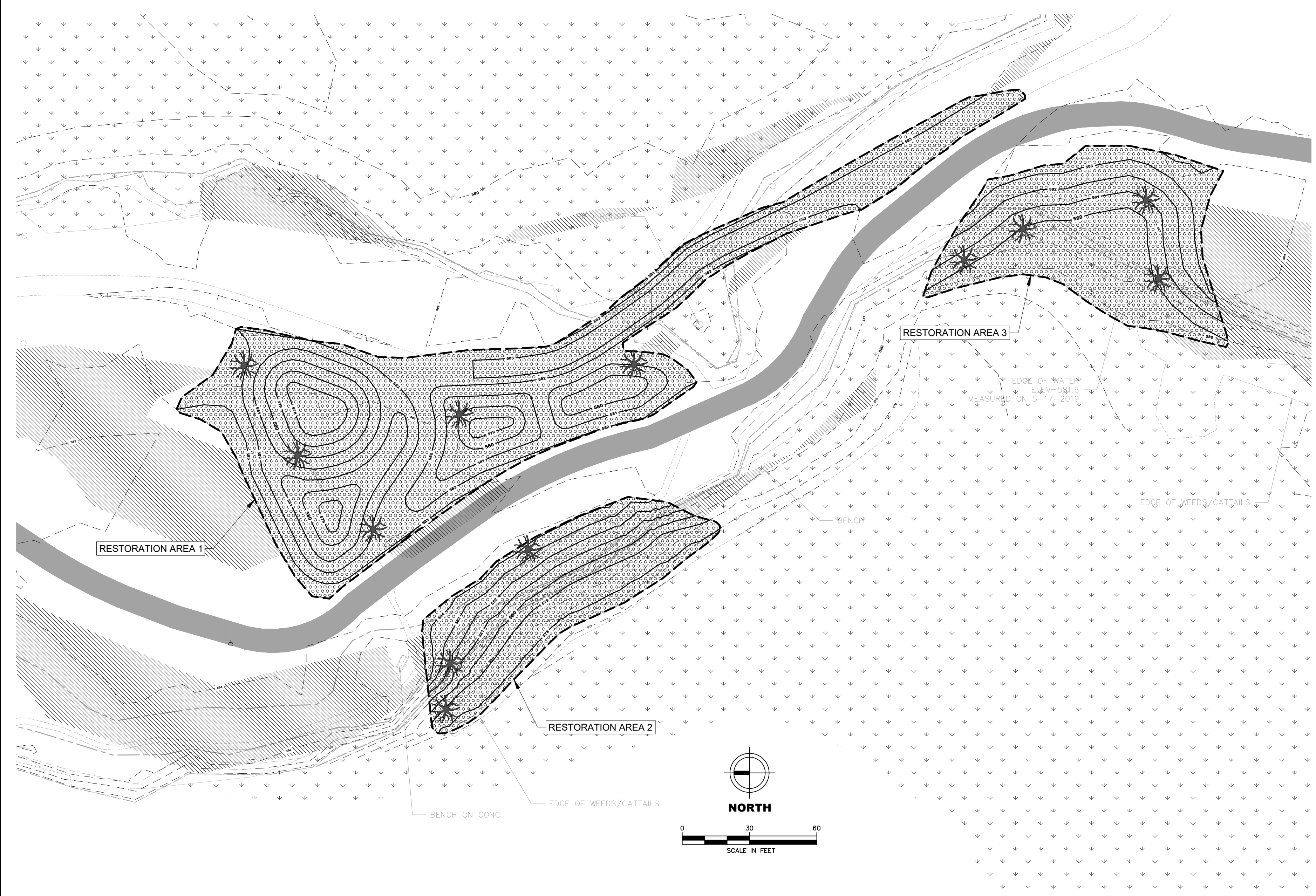


Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project

WORK AREAS 1, 2, & 3

DWG. NO.
C6
ISSUE
3

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EXISTING FEATURES LEGEND

- EX. WATER ELEV.
- EX. WATER ELEV. (MUSKEGON RIVER)
- ORDINARY HIGH WATER MARK (OHWM)
- 100-YR. FLOOD ELEV.
- MUSKEGON RIVER THALWEG
- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- WETLANDS
- CONCRETE / ASPHALT
- GRAVEL
- BENCHMARK

PROPOSED FEATURES LEGEND

- GRADING LIMITS
- MAJOR CONTOUR
- MINOR CONTOUR

RESTORATION AREAS LEGEND

- MESIC NORTHERN FOREST SEED MIX AREA
- FLOODPLAIN FOREST SEED MIX AREA

HABITAT STRUCTURES

- LARGE WOODY DEBRIS

NOTES

- 1) Benchmark #4A elevation 592.97'. Location at southwest corner of 'Community Events' sign on Lake Ave, east of entrance to the nature preserve. NAVD88 Via VRS, OPUS & GPS OBSV.
- 2) Water elevation measured on 5/17/19 and 4/28/14. Water elevation varies depending on location.
- 3) OHWM elevation is 581.5'.
- 4) 100-YR Floodplain Elevation is 584.4'.
- 5) Muskegon River information from previous 2014 Project (F&V #819060).

RESTORATION NOTES

- 1) See plant lists for quantities and species information on sheet D2.
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- 3) Habitat structures shall be placed throughout the restoration areas at an approximate rate of one habitat structure per 500 square feet of restoration area. Details for habitat structures can be found on sheet D1, however this is not an exhaustive list and the contractor is expected to provide examples of potential habitat structures to be installed throughout the restoration area. All proposed habitat structures to be approved by the engineer.
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2	10/10/19	90 % CONSTRUCTION DOCUMENTS	WL
1	8/5/19	PRELIMINARY CONCEPTS	WL

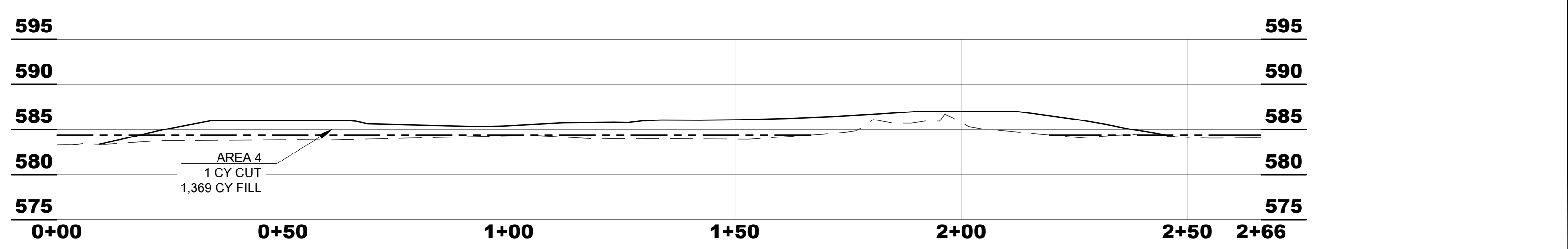
Designed:	- BM
Checked:	- BM
Drawn:	- WL
Submitted By:	- BM
P.E. Number:	- 44371
Submittal Date:	- 3/9/20

GEI Consultants
5525 Edgewater Drive
Allendale, MI 49401

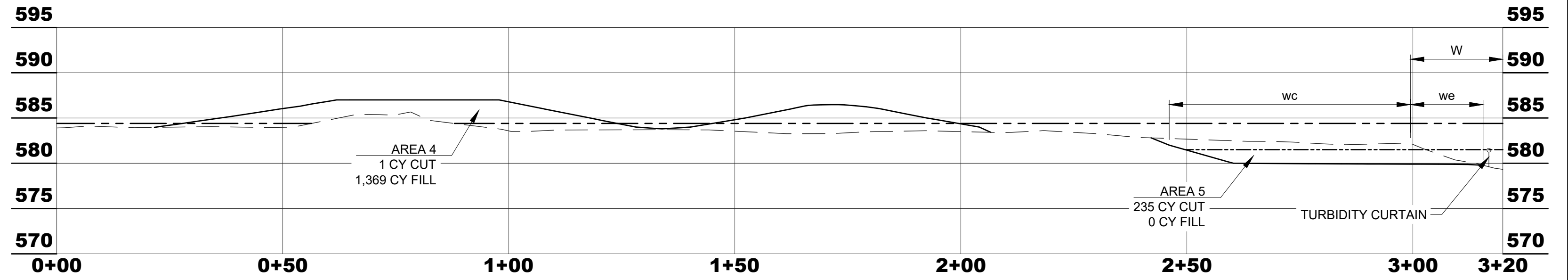
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Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project
RESTORATION AREAS 1, 2, & 3

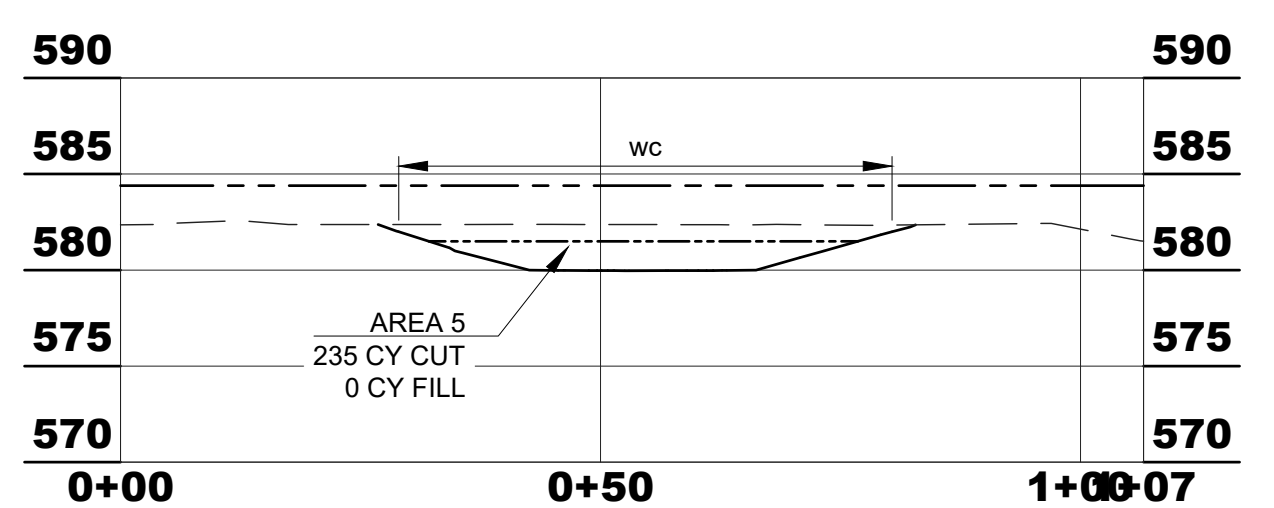
DWG. NO.
C7
ISSUE
3



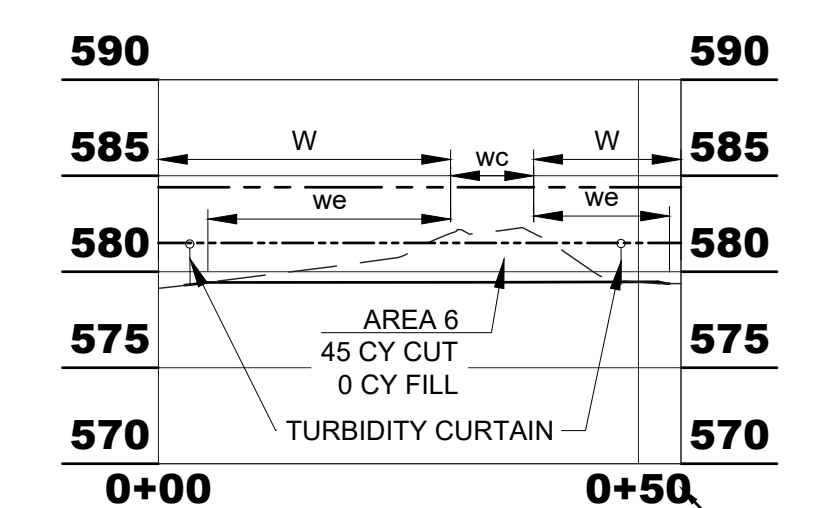
CROSS-SECTION F-F'
SCALE H: 1"=20' V: 1"=10'



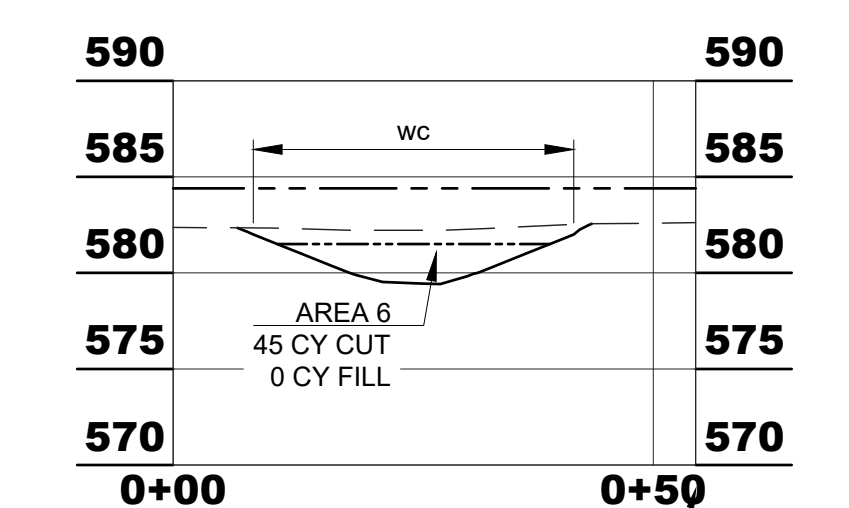
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SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION H-H'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION I-I'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION J-J'
SCALE H: 1"=20' V: 1"=10'

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- DELINEATED WETLAND BOUNDARY
- MINOR CONTOUR
- MINOR CONTOUR
- WETLANDS

PROPOSED FEATURES LEGEND

- CONCRETE / ASPHALT
- GRAVEL
- BENCHMARK
- GRADING LIMITS
- MAJOR CONTOUR
- MINOR CONTOUR
- TURBIDITY CURTAIN
- SECTION MARKER
- SECTION ID
- SHEET #

WETLAND LEGEND

- WETLAND IMPACT AREAS (FILL)
- WETLAND ENHANCEMENT AREAS (CUT)
- WETLAND CREATION AREAS (EXCAVATION IN UPLAND)
- DEBRIS PILE REMOVAL

AREA 4 EARTHWORK	
VOL (CY)	AREA (SF)
CUT	1
FILL	1,369
NET	1,368 FILL

AREA 4 OHWM IMPACTS	
VOL (CY)	AREA (SF)
CUT	0
FILL	0
NET	-

AREA 4 100-YR FLOOD IMPACTS	
VOL (CY)	AREA (SF)
CUT	1
FILL	444
NET	444 FILL

AREA 4 WETLAND IMPACTS	
VOL (CY)	AREA (SF)
CUT	0
FILL	0
NET	-

AREA 5 EARTHWORK	
VOL (CY)	AREA (SF)
CUT	235
FILL	0
NET	235 CUT

AREA 5 OHWM IMPACTS	
VOL (CY)	AREA (SF)
CUT	28
FILL	0
NET	28 CUT

AREA 5 100-YR FLOOD IMPACTS	
VOL (CY)	AREA (SF)
CUT	235
FILL	0
NET	235 CUT

AREA 5 WETLAND IMPACTS	
VOL (CY)	AREA (SF)
CUT	53
FILL	0
NET	53 CUT

AREA 6 EARTHWORK	
VOL (CY)	AREA (SF)
CUT	45
FILL	0
NET	45 CUT

AREA 6 OHWM IMPACTS	
VOL (CY)	AREA (SF)
CUT	17
FILL	0
NET	17 CUT

AREA 6 100-YR FLOOD IMPACTS	
VOL (CY)	AREA (SF)
CUT	45
FILL	0
NET	45 CUT

AREA 6 WETLAND IMPACTS	
VOL (CY)	AREA (SF)
CUT	36
FILL	0
NET	36 CUT

CROSS-SECTION LEGEND

- EXISTING GRADE
- PROPOSED GRADE
- OHWM
- 100-YR. FLOOD
- EXISTING WETLAND
- WETLAND IMPACTS
- WETLAND ENHANCEMENT
- WETLAND CREATION

- NOTES**
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NO.	DATE	ISSUE/REVISION	APP

Scale: 1" = 30' (Scale in Feet)

BEFORE YOU DIG CALL MISS DIG
CALL 3 FULL WORKING DAYS: 811
1-800-482-7171

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Submittal Date: - 8/6/20

GEI PN 1901441

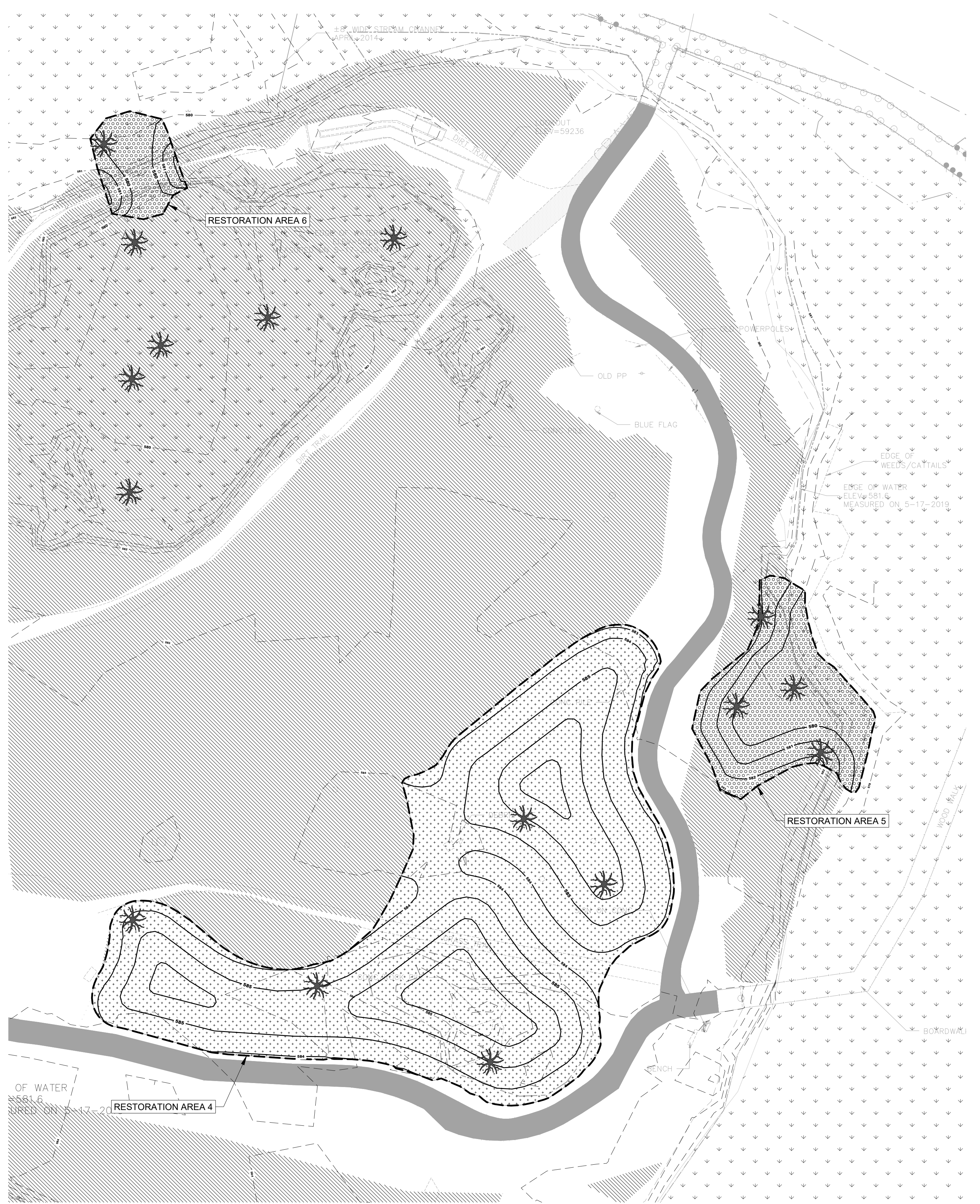
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Allendale, MI 49401

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WORK AREAS 4, 5, & 6

DWG. NO. **C8**
ISSUE **3**



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PROPOSED FEATURES LEGEND

- GRADING LIMITS
- MAJOR CONTOUR
- MINOR CONTOUR

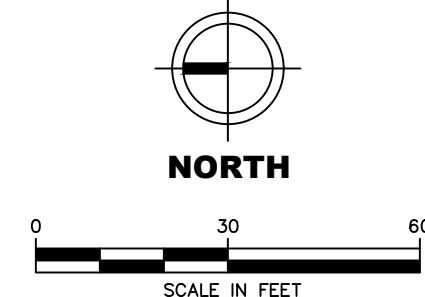
RESTORATION AREAS LEGEND

- MESIC NORTHERN FOREST SEED MIX AREA
- FLOODPLAIN FOREST SEED MIX AREA
- OAK-PINE BARRENS SEED MIX AREA

HABITAT STRUCTURES

- LARGE WOODY DEBRIS

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REGIONAL DEVELOPMENT COMMISSION
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Muskegon, MI 49440

Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project
RESTORATION AREAS 4, 5, & 6

DWG. NO. **C9**
ISSUE **3**

AREA 7 EARTHWORK		
VOL (CY)	AREA (SF)	
CUT	2,570	44,880
FILL	0	-
NET	2,570 CUT	44,880

AREA 7 OHWM IMPACTS		
VOL (CY)	AREA (SF)	
CUT	229	8,711
FILL	0	0
NET	229 CUT	8,711

AREA 7 100-YR FLOOD IMPACTS		
VOL (CY)	AREA (SF)	
CUT	2,304	30,793
FILL	0	-
NET	2,304 CUT	30,793

AREA 7 WETLAND IMPACTS		
VOL (CY)	AREA (SF)	
CUT	461	12,019
FILL	0	0
NET	461 CUT	12,019

*WETLAND CREATION: 12,431 SF (0.29 AC)

AREA 8 EARTHWORK		
VOL (CY)	AREA (SF)	
CUT	744	18,624
FILL	0	-
NET	744 CUT	18,624

AREA 8 OHWM IMPACTS		
VOL (CY)	AREA (SF)	
CUT	500	17,223
FILL	0	0
NET	500 CUT	17,223

AREA 8 100-YR FLOOD IMPACTS		
VOL (CY)	AREA (SF)	
CUT	744	18,624
FILL	0	-
NET	744 CUT	18,624

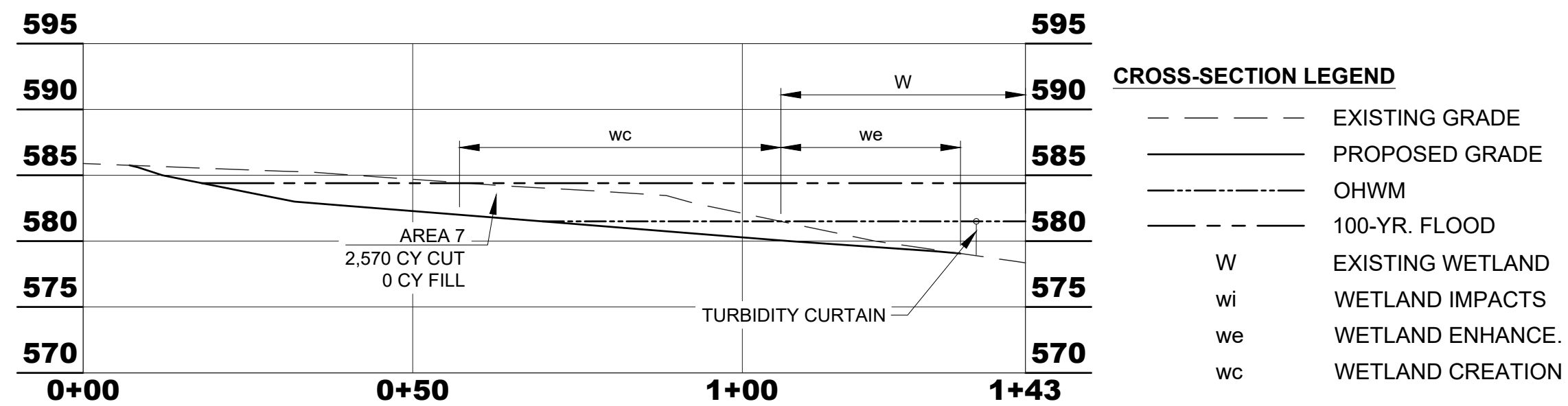
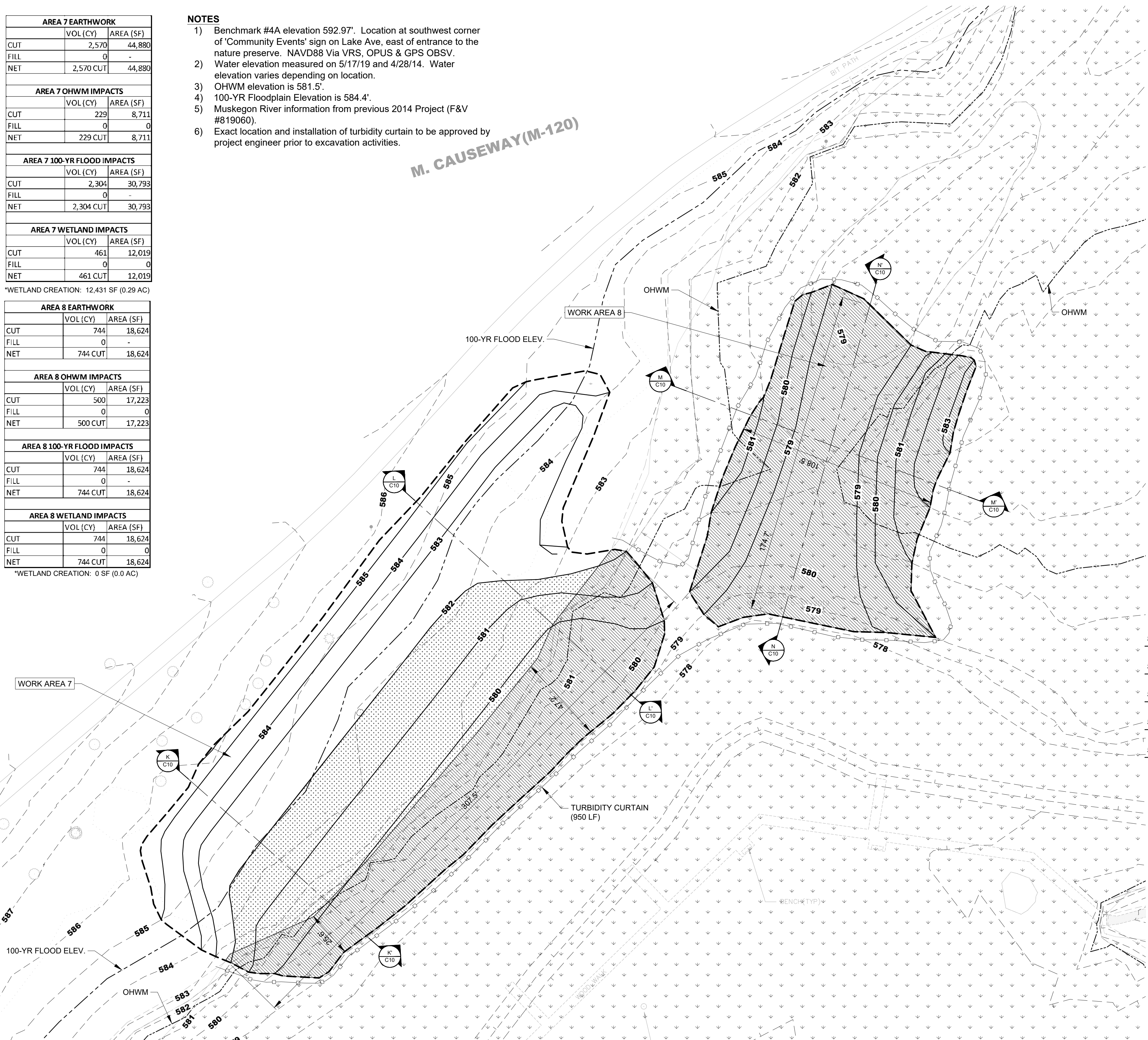
AREA 8 WETLAND IMPACTS		
VOL (CY)	AREA (SF)	
CUT	744	18,624
FILL	0	0
NET	744 CUT	18,624

*WETLAND CREATION: 0 SF (0.0 AC)

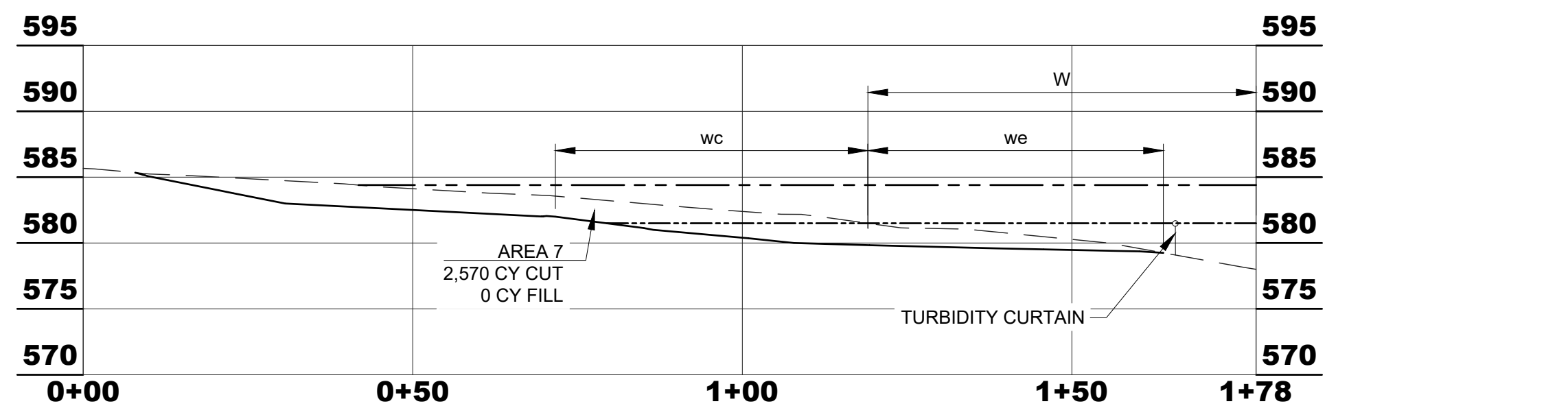
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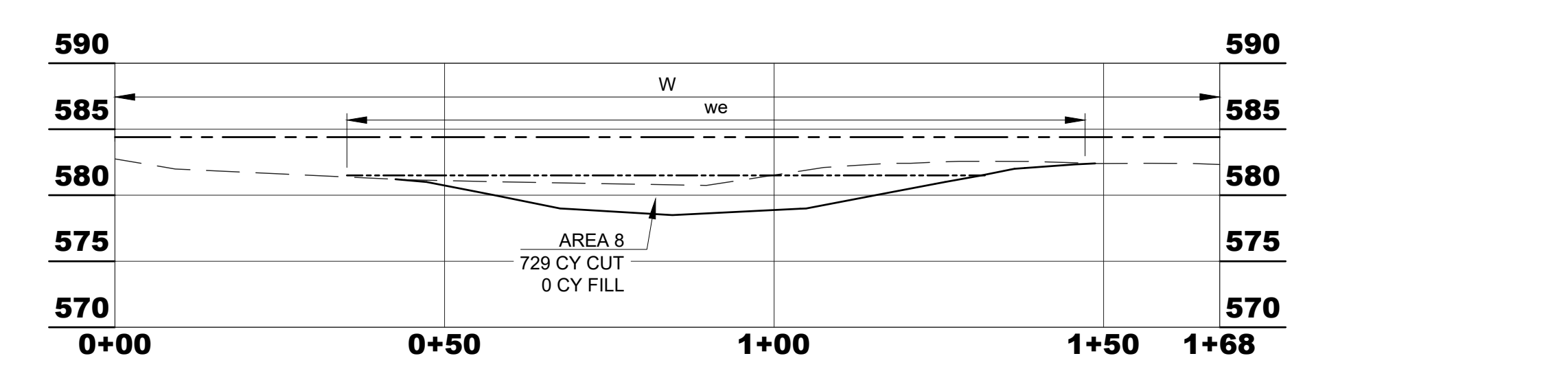
M. CAUSEWAY (M-120)



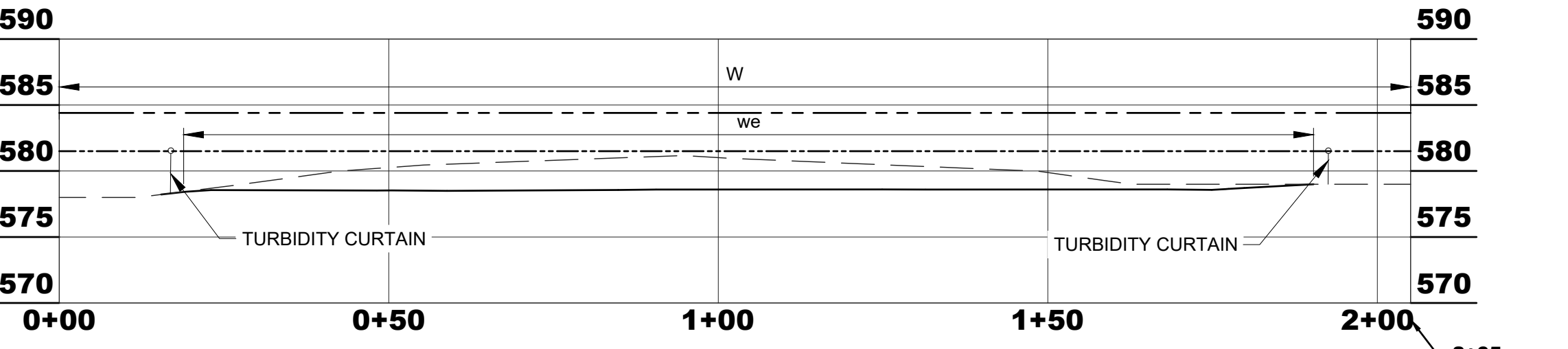
CROSS-SECTION K-K'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION L-L'
SCALE H: 1"=20' V: 1"=10'

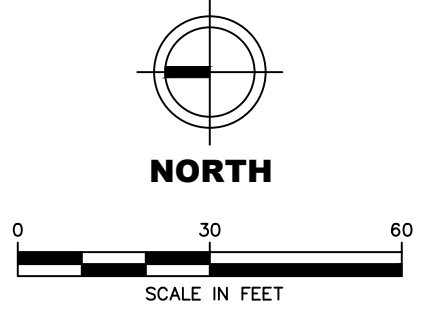


CROSS-SECTION M-M'
SCALE H: 1"=20' V: 1"=10'



CROSS-SECTION N-N'
SCALE H: 1"=20' V: 1"=10'

<p>EXISTING FEATURES LEGEND</p> <ul style="list-style-type: none"> --- EX. WATER ELEV. --- EX. WATER ELEV. (MUSKEGON RIVER) --- ORDINARY HIGH WATER MARK (OHWM) --- 100-YR FLOOD ELEV. --- MUSKEGON RIVER THALWEG --- DELINEATED WETLAND BOUNDARY --- MINOR CONTOUR --- MINOR CONTOUR --- WETLANDS --- CONCRETE / ASPHALT --- GRAVEL 	<p>PROPOSED FEATURES LEGEND</p> <ul style="list-style-type: none"> --- GRADING LIMITS --- MAJOR CONTOUR --- MINOR CONTOUR --- TURBIDITY CURTAIN --- SECTION MARKER --- WETLAND IMPACT AREAS (FILL) --- WETLAND ENHANCEMENT AREAS (CUT) --- WETLAND CREATION AREAS (EXCAVATION IN UPLAND) --- DEBRIS PILE REMOVAL
--	--



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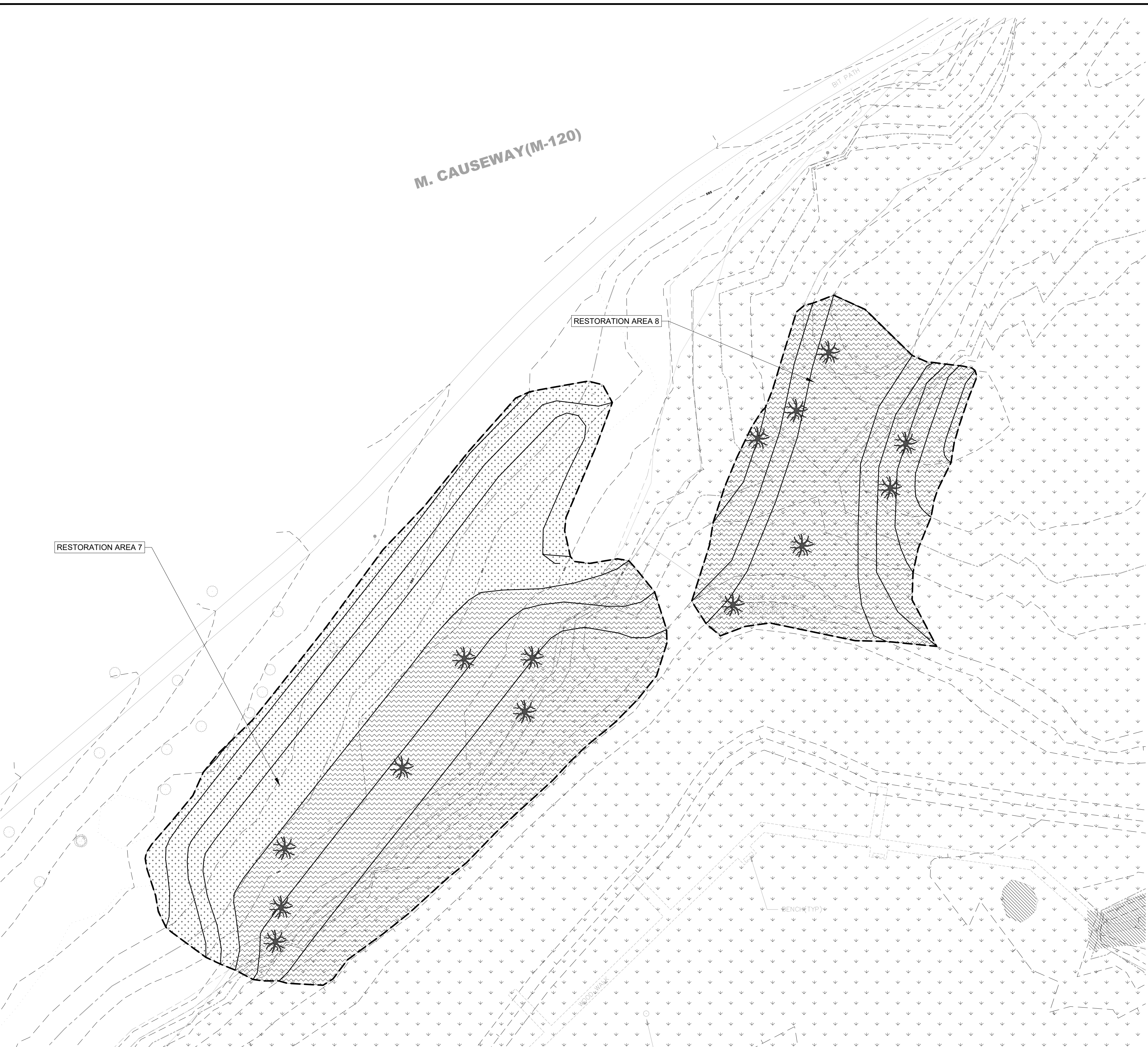
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WORK AREAS 7 & 8

DWG. NO. **C10**
ISSUE **3**

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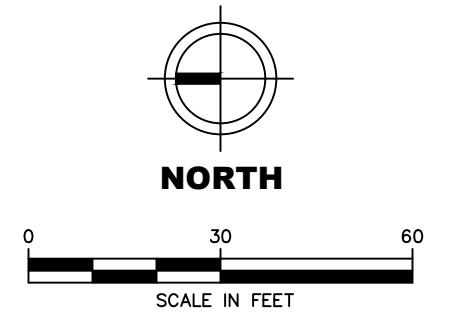
PROPOSED FEATURES LEGEND

- GRADING LIMITS
- MAJOR CONTOUR
- MINOR CONTOUR

RESTORATION AREAS LEGEND

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- FLOODPLAIN FOREST SEED MIX AREA
- OAK-PINE BARRENS SEED MIX AREA
- GREAT LAKES MARSH SEED MIX AREA

- HABITAT STRUCTURES**
- LARGE WOODY DEBRIS



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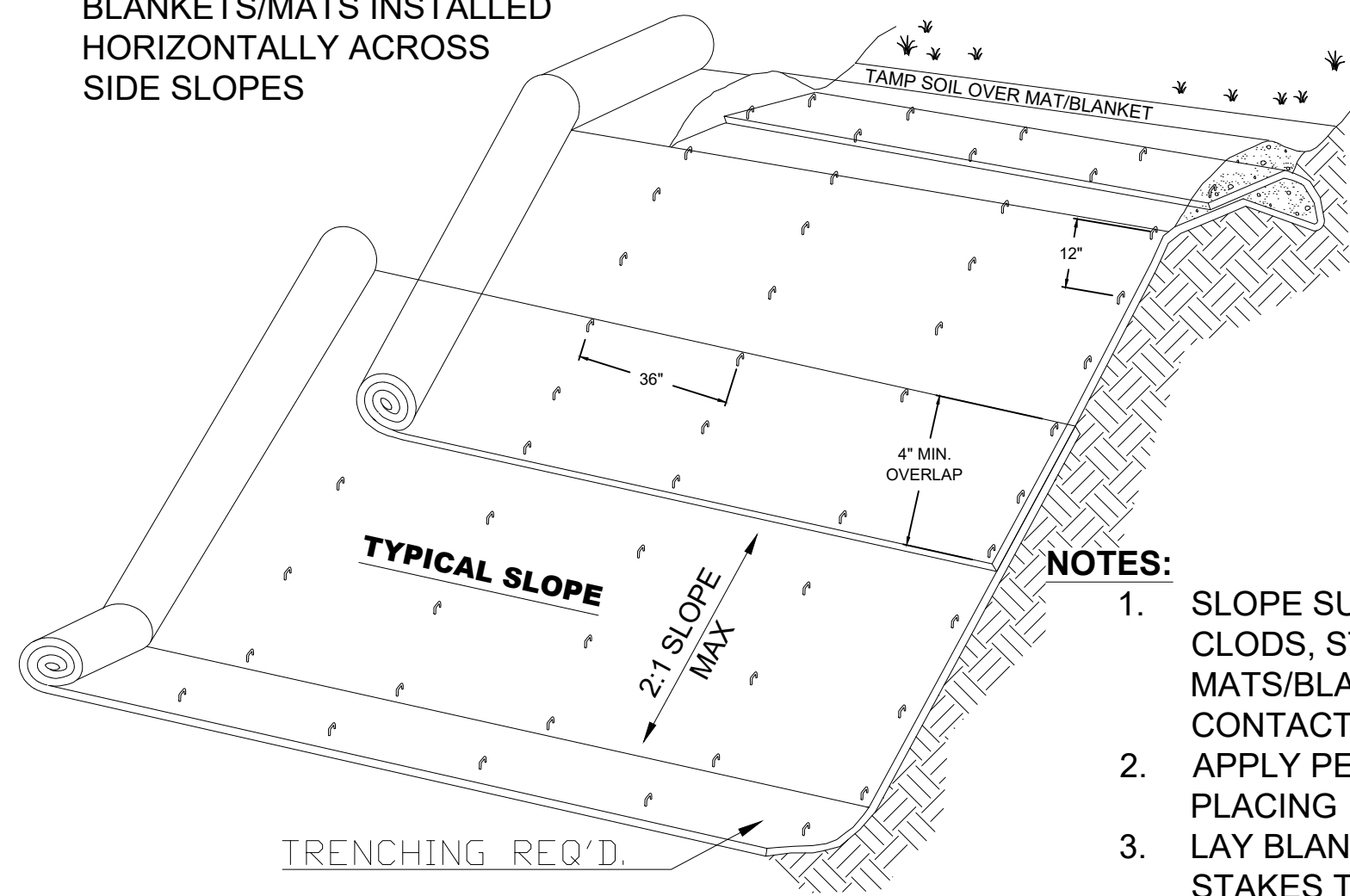
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RESTORATION AREAS 7 & 8

DWG. NO.
C11
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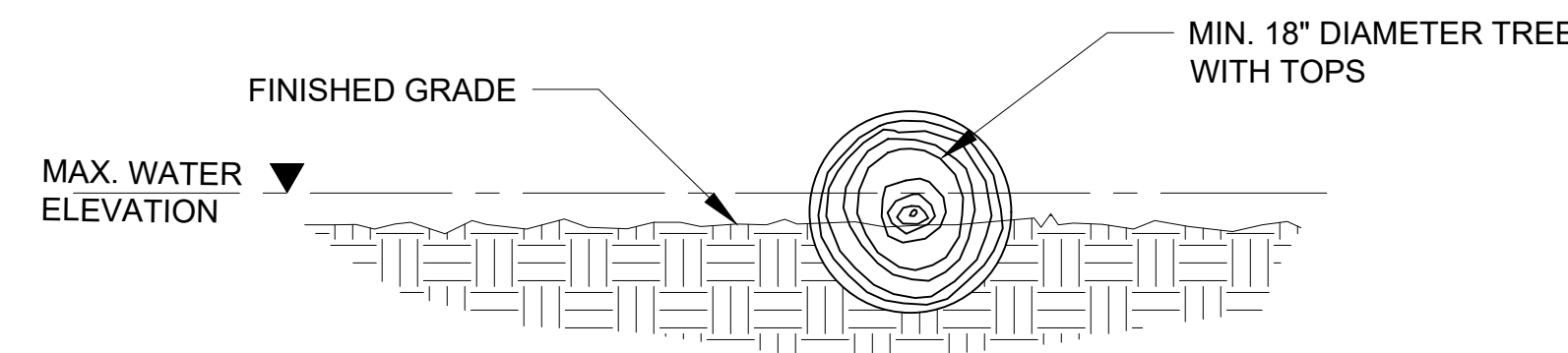
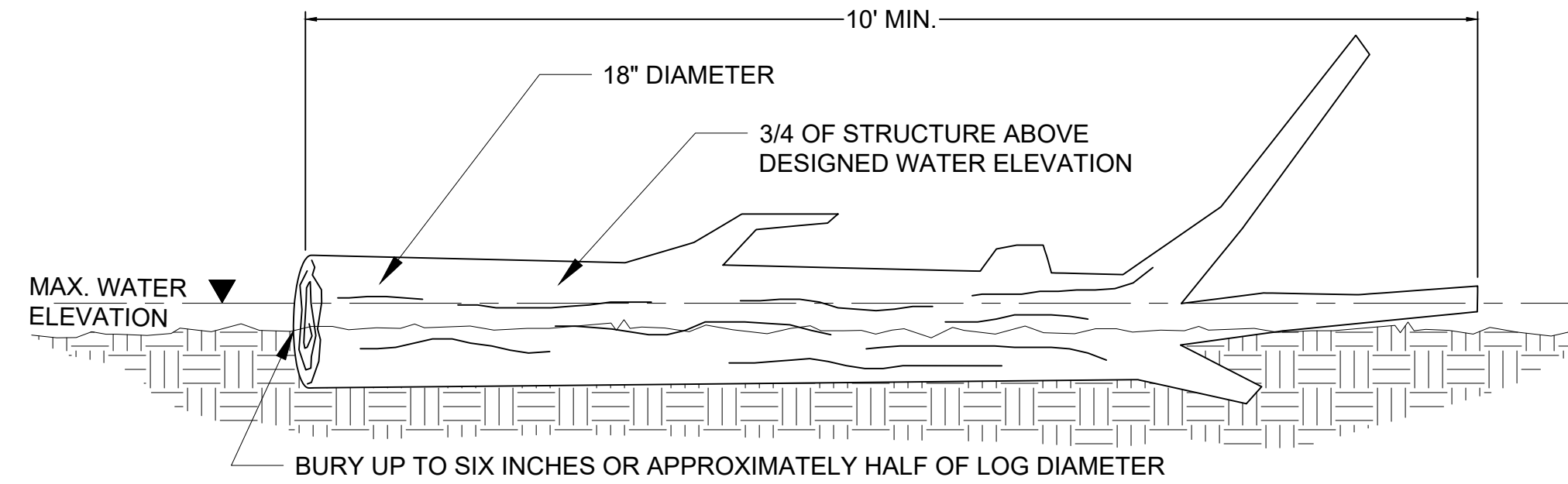
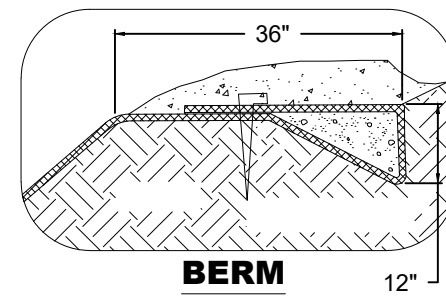
BLANKETS/MATS INSTALLED
HORIZONTALLY ACROSS
SIDE SLOPES



NOTES:

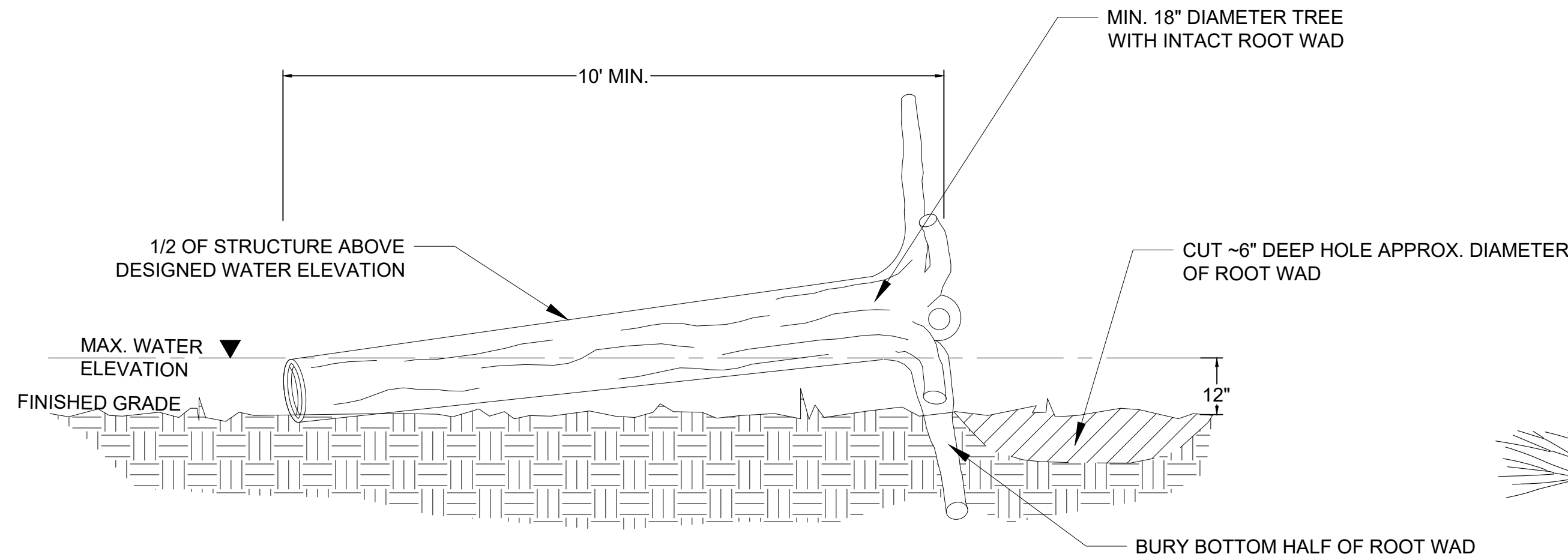
1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS
3. LAY BLANKETS LOOSELY AND USE WOODEN STAKES TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

STAPLES



EROSION CONTROL BLANKET

NOT TO SCALE



HABITAT ROOT WAD STRUCTURE - SIDE VIEW

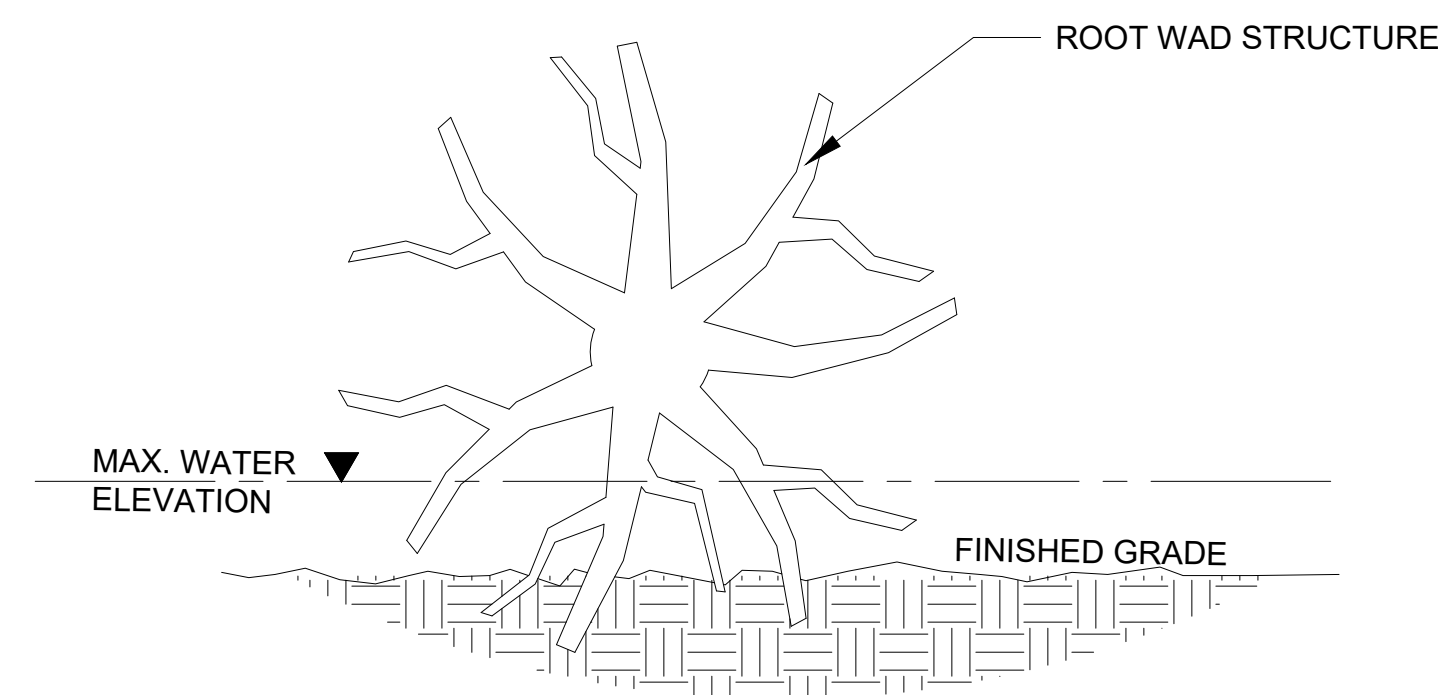
NOT TO SCALE

HABITAT STRUCTURE NOTES

- 1) Habitat structures to be constructed from durable hardwood species such as oak or maple. Other tree species for habitat structures to be approved by the engineer.
- 2) Root wads and snags should have fine branches left in tact when they are placed in the water for fish habitat and egg laying substrate for amphibians. This is especially important for logs placed in vernal pools.

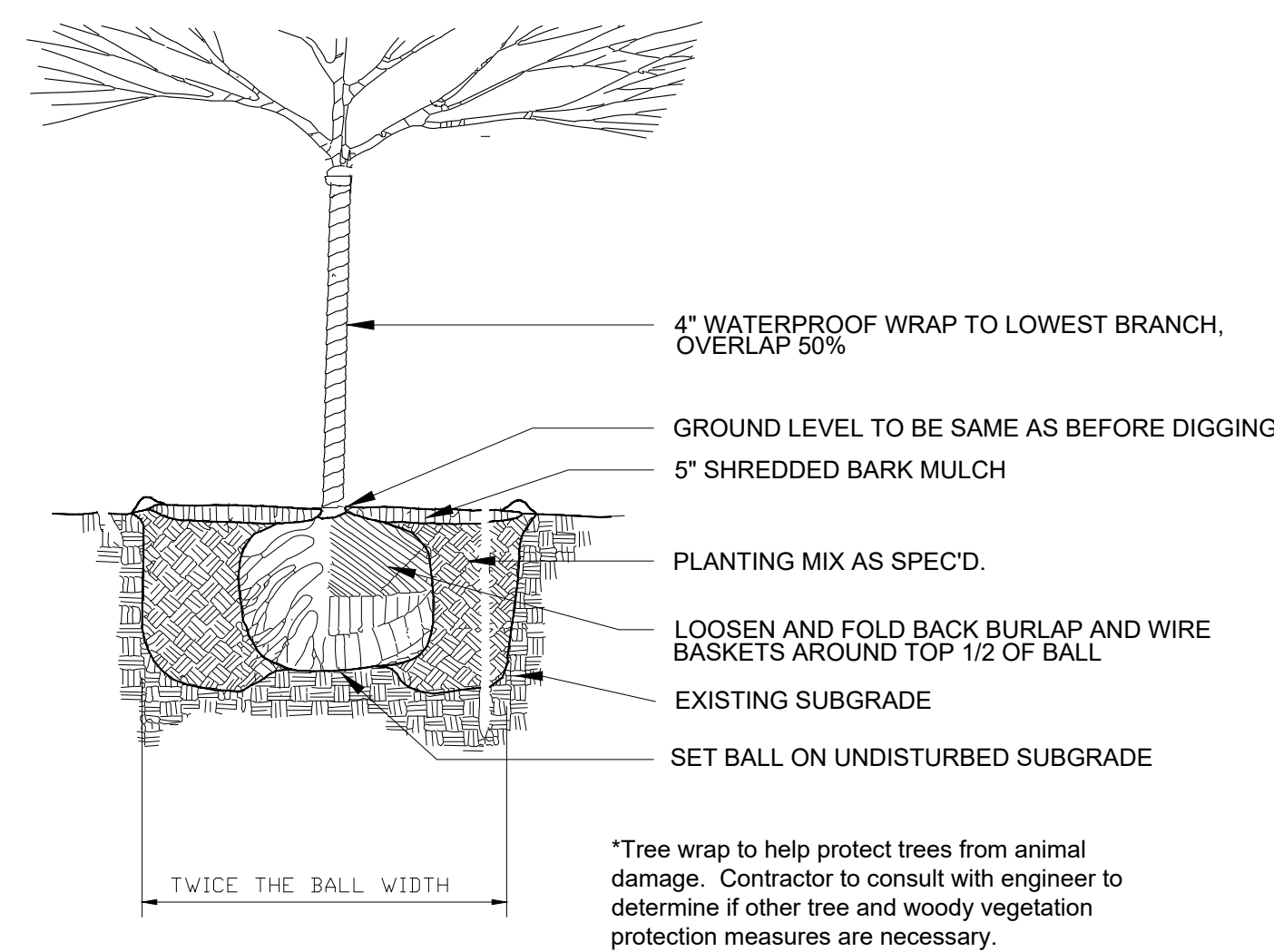
HABITAT LOG STRUCTURE

NOT TO SCALE



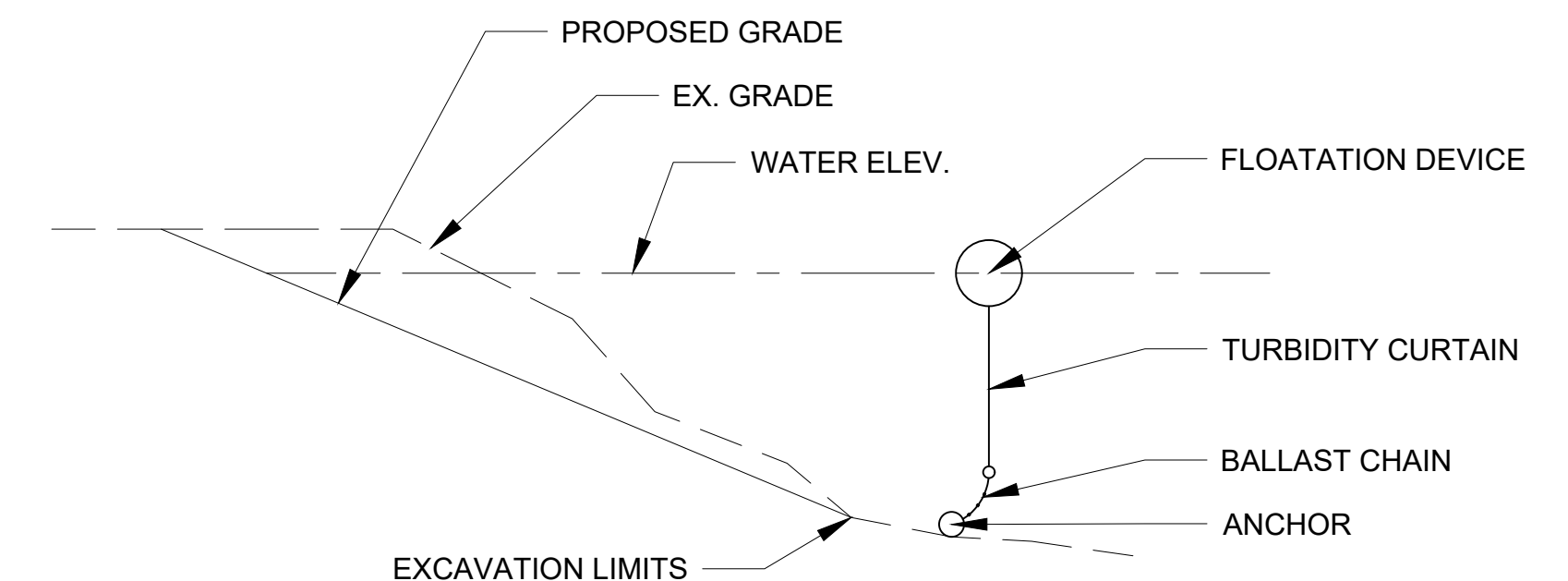
HABITAT ROOT WAD STRUCTURE - LOOKING AT ROOTS

NOT TO SCALE



BALLED AND BURLAPPED (B&B) TREE PLANTING DETAIL

NOT TO SCALE



TURBIDITY CURTAIN DETAILS

NOT TO SCALE

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MERES Fish and Wildlife Habitat
Restoration Project

DETAILS

DWG. NO.

D1

ISSUE

3

Scientific Name	Common Name	Wetland Indicator Status	Water Depth	Area 1 (17,545 sf)	Area 2 (5918 sf)	Area 3 (7339 sf)	Area 4 (28,010 sf)	Area 5 (5,050 sf)	Area 6 (1,621 sf)	Area 7 (44,880 sf)	Area 8 (22,715 sf)	Inv Species Removal Areas (4.5 ac)
<i>Allium cernuum</i>	Nodding wild onion	FACU					456					
<i>Aquilegia canadensis</i>	Wild columbine	FACU					456					
<i>Asclepia incarnata</i>	Swamp milkweed	OBL			114	114		76		114		
<i>Asclepias tuberosa</i>	Butterfly weed	UPL					494			380		
<i>Athyrium filix-femina</i>	Lady fern	FAC		25								200
<i>Ceanothus americanus</i>	New Jersey tea	UPL					456					
<i>Chelone glabra</i>	Turtlehead	OBL		380	114	114		76				
<i>Dryopteris marginalis</i>	Leatherleaf woodfern	FACU		25	10	10		10				200
<i>Euphorbia corollata</i>	Flowering spurge	UPL					456					
<i>Eutrochium maculatum</i>	Joe-Pye weed	OBL								152		
<i>Eutrochium purpureum</i>	Purple joe-pye weed	FAC					456					
<i>Helianthus divaricatus</i>	Woodland sunflower	UPL					456					
<i>Hibiscus moscheutos</i>	Rose mallow	OBL			114	114		114		380		
<i>Iris virginica shrevei</i>	Blue flag iris	OBL		520	152	190		152		560		
<i>Liatris aspera</i>	Rough blazing star	UPL					380			114		
<i>Liatris cylindracea</i>	Cylindrical blazing star	FAC					380					
<i>Liatris spicata</i>	Marsh blazing star	FAC								380		
<i>Lobelia cardinalis</i>	Cardinal flower	OBL		380	152	190		76		380		
<i>Lobelia siphilitica</i>	Blue lobelia	FACW+					380					
<i>Mimulus ringens</i>	Monkeyflower	OBL								380		
<i>Monarda fistulosa</i>	Wild bergamot	FACU					380			380		
<i>Monarda punctata</i>	Horse mint/ dotted mint	UPL					380					
<i>Nuphar advena</i>	Spatterdock	OBL				76				760	400	
<i>Nymphaea tuberosa</i>	White water lily	OBL				76				760	400	
<i>Osmunda cinnamomeum</i>	Cinnamon fern	FACW		100	15	15		15				
<i>Osmunda regalis</i>	Royal fern	OBL		100	15	15		15				
<i>Peltandra virginica</i>	Arrow arum	OBL			152	152		152		760		
<i>Phlox pilosa</i>	Sand prairie phlox	FACU					494					
<i>Physostegia virginiana</i>	Obedient plant/ false dragonhead	FACW+					494					
<i>Pontederia cordata</i>	Pickersweed	OBL			152	152		114		760	500	
<i>Pycnanthemum virginianum</i>	Common mountain mint	FACW+					494					
<i>Sagittaria latifolia</i>	Arrowhead	OBL								760	500	
<i>Saururus cernuus</i>	Lizard's tail	OBL		380	114	152		114				
<i>Solidago speciosa</i>	Show goldenrod	UPL					494					
<i>Tradescantia ohiensis</i>	Common spiderwort	FACU					380					
<i>Veronicastrum virginicum</i>	Culver's root	FAC					456			114		
<i>Carex crinita</i>	Fringed sedge	OBL		520								
<i>Carex lupulina</i>	Hop sedge	OBL										
<i>Carex muskingumensis</i>	Sand bracted sedge	OBL		520								
<i>Carex stricta</i>	Tussock sedge	OBL		520						570		
<i>Carex vulpinoidea</i>	Brown fox sedge	OBL								570		
<i>Juncus effusus</i>	Soft rush	OBL								570		
<i>Schoenoplectus acutus</i>	Hardstem bulrush	OBL								760		
<i>Schoenoplectus pungens</i>	Common threesquare	OBL			152	190		152		760		
<i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	OBL			152	190		152			380	
<i>Scirpus cyperinus</i>	Wool Grass	OBL								152		
<i>Sparganium eurycarpum</i>	Common burreed	OBL			114	152		114		760	380	
Total (by zone)				3,470	1,522	1,902	7,030	1,332	0	11,276	2,560	
Shrubs (24-36" bare root, 8' spacing)												
<i>Aronia melanocarpa</i>	Black chokeberry	FACW			10	15		10				250
<i>Ceanothus americanus</i>	New Jersey Tea	UPL					200					200
<i>Cornus amomum</i>	Silky dogwood	FACW+			10	10		10				100
<i>Cornus sericea</i>	Red-osier dogwood	FACW+			10	10		10				100
<i>Dierilla lonicera</i>	Northern bush honeysuckle	UPL			10	10		10				500
<i>Ilex verticillata</i>	Winterberry	FACW			10	10		10				100
<i>Myrica gale</i>	Sweet gale	OBL			10	10		10				200
<i>Physocarpus opulifolius</i>	Ninebark	FACW			10	10		10				200
<i>Sambucus canadensis</i>	Elderberry	FACW-			10	25		10				250
<i>Symphoricarpos albus var. laevigatus</i>	Snowberry	FACU			10	10		10				250
<i>Vaccinium angustifolium</i>	Low bush blueberry	FACU			10	10		10				250
<i>Viburnum dentatum</i>	Arrowwood	FAC			10	10		10				250
<i>Viburnum lentago</i>	Nannyberry	FAC			10	10		10				250
<i>Viburnum opulus v. americanum</i>	American highbush cranberry	FACW			10	10		10				250
Total (by zone)				0	130	150	200	130	0	0	0	3150
Trees (minum 24", 390/acre)												
<i>Acer rubrum</i>	Red maple	FAC			5	10		5				75
<i>Celtis occidentalis</i>	Hackberry	FAC			5	10						75
<i>Cercis canadensis</i>	Redbud	FACU										50
<i>Cornus florida</i>	Flowering dogwood	FACU										50
<i>Juniperus virginiana</i>	Eastern red cedar	FACU										300
<i>Nyssa sylvatica</i>	Black gum	FACW+										100
<i>Pinus strobus</i>	White pine	FACU			5	10		5				300
<i>Platanus occidentalis</i>	Sycamore	FACW			5	10		5				150
<i>Prunus serotina</i>	Wild black cherry	FACU										200
<i>Quercus bicolor</i>	Swamp white oak	FACW+			5			5				75
<i>Quercus palustris</i>	Pin oak	FACW			5			5				75
<i>Tsuga canadensis</i>	Eastern hemlock	FACU										300
Total (by zone)				0	30	40	0	25	0	0	0	1750
Trees (min 6' tall)												
<i>Acer rubrum</i>	Red maple	FAC			3	2		1				10
<i>Celtis occidentalis</i>	Hackberry	FAC										10
<i>Cercis canadensis</i>	Redbud	FACU				2		1				5
<i>Cornus florida</i>	Flowering dogwood	FACU										5
<i>Juniperus virginiana</i>	Eastern red cedar	FACU						5				35
<i>Nyssa sylvatica</i>	Black gum	FACW+			2							10
<i>Picea glauca</i>	White spruce	FACU						5				25
<i>Pinus strobus</i>	Eastern white pine	FACU			3	4	10	3				35
<i>Platanus occidentalis</i>	Sycamore	FACW				3		4				20
<i>Prunus serotina</i>	Wild black cherry	FACU										15
<i>Quercus bicolor</i>	Swamp white oak	FACW+			4	3		3				10
<i>Quercus palustris</i>	Pin oak	FACW						10				10
<i>Tsuga canadensis</i>	Eastern hemlock	FACU			3	4	5					35
Total (by zone)				0	15	18	35	12	0	0	0	225

*All herbaceous plants to be installed 2' on center - except in the vernal pools in area 1 which would be installed 3' on center.

Attention:	5	3/9/20	100 % CONSTRUCTION DOCUMENTS - 3	WL
	4	1/27/20	100 % CONSTRUCTION DOCUMENTS - 2	WL
	3	12/12/19	100 % CONSTRUCTION DOCUMENTS	WL
	2	10/10/19	90 % CONSTRUCTION DOCUMENTS	WL
	1	8/5/19	PRELIMINARY CONCEPTS	WL
NO.	DATE	ISSUE/REVISION	APP	

Designed:	- BM
Checked:	- BM
Drawn:	- WL
Submitted By:	- BM
P.E. Number:	- 44371
Submittal Date:	- 3/9/20

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Muskegon Lake Nature Preserve
MERES Fish and Wildlife Habitat
Restoration Project

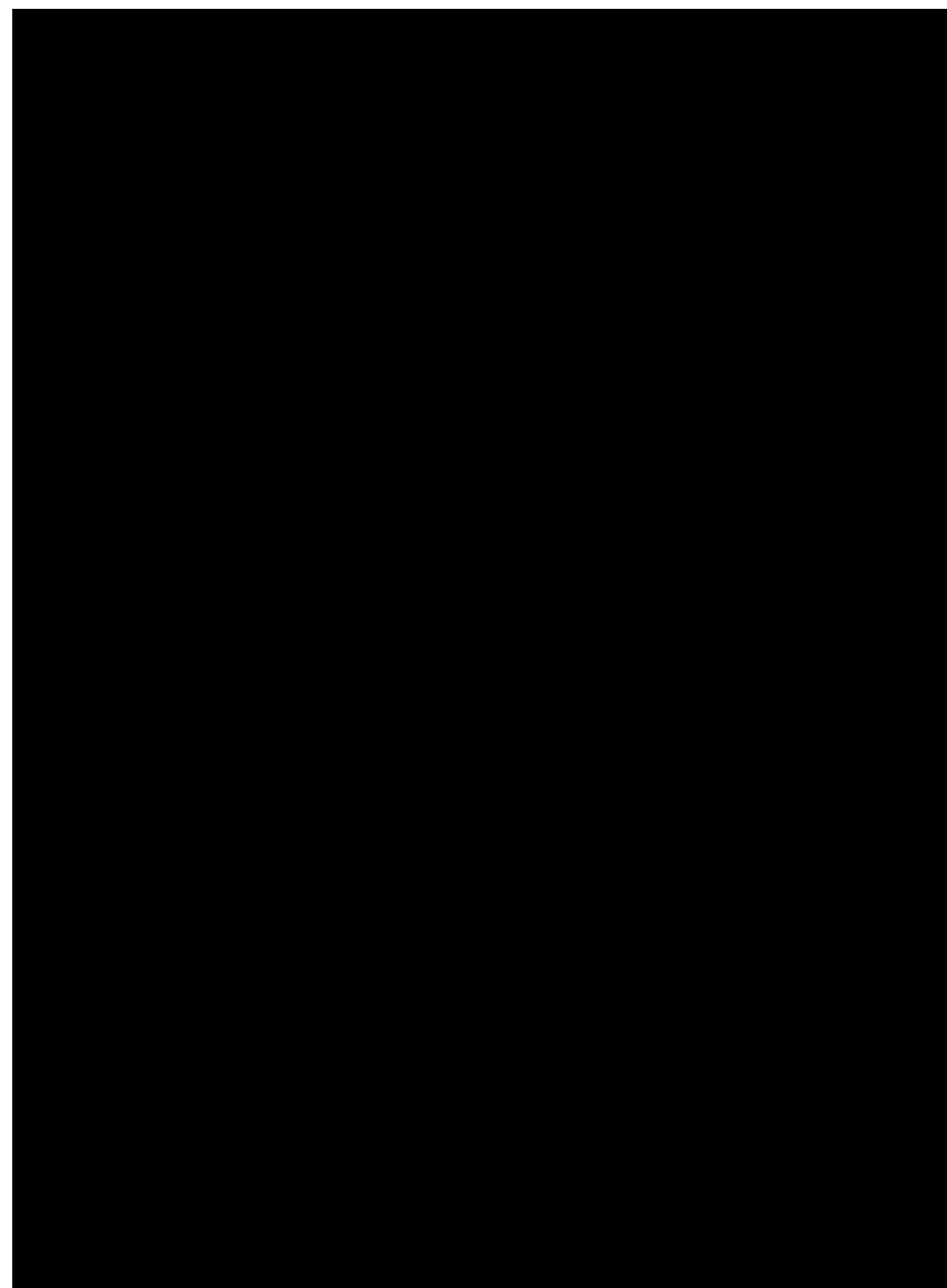
PLANT LISTS

DWG. NO. **D2**
ISSUE **3**

MESIC NORTHERN FOREST SEED MIX - ALL INVASIVE SPECIES REMOVAL AREAS
(194,753 SF; 4.5 AC)



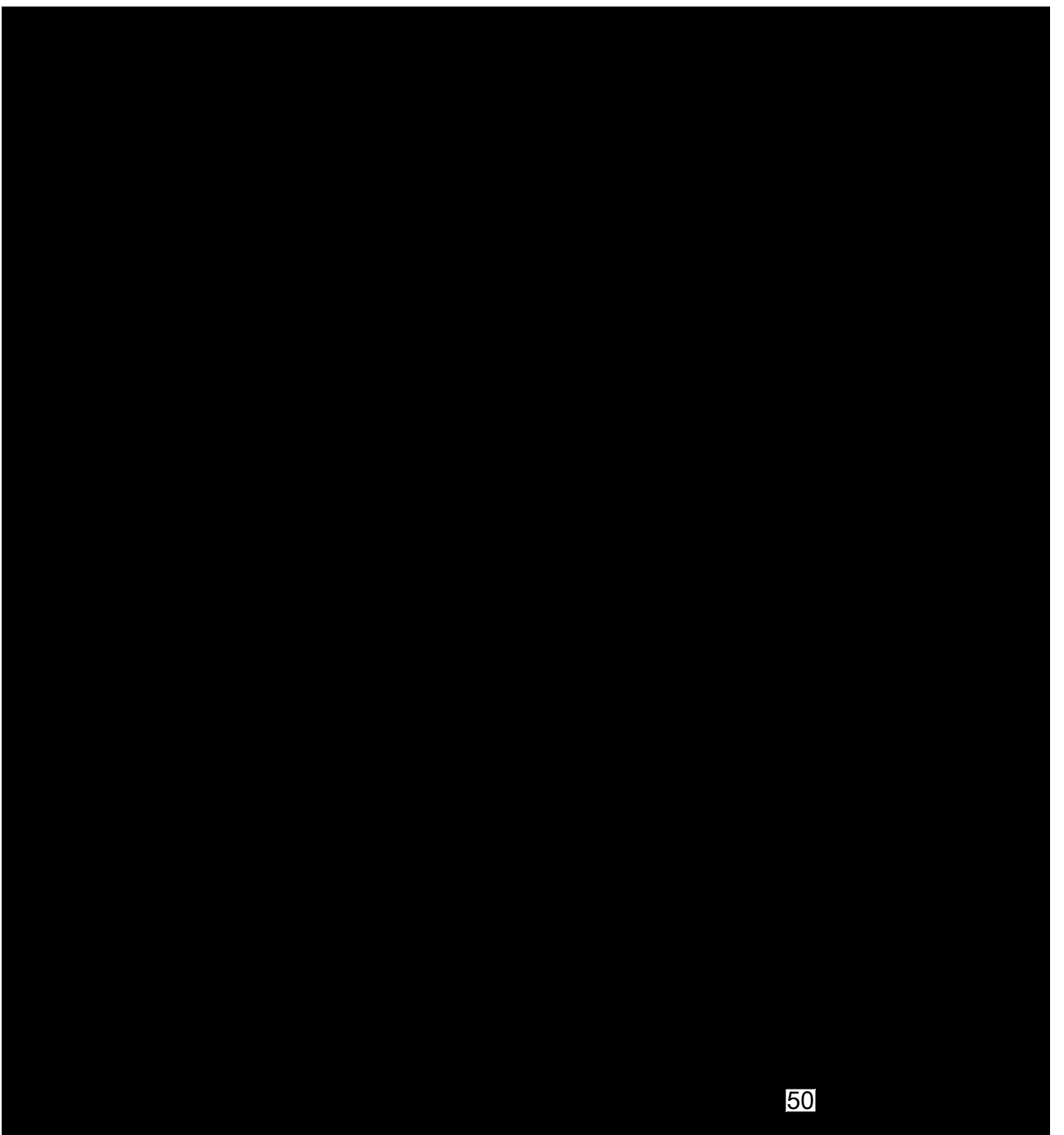
OAK-PINE BARRENS SEED MIX - AREA 4 AND UPLAND AREA OF AREA 7
(48,435 SF; 1.1 AC)



FLOODPLAIN FOREST SEED MIX - AREAS 1, 2, 3, 5, & 6
(37,475 SF; 0.9 AC)



GREAT LAKES MARSH SEED MIX - AREAS 7 & 8
(43,076 SF; 1.0 AC)



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Appendix A: Ecological Restoration Plans
