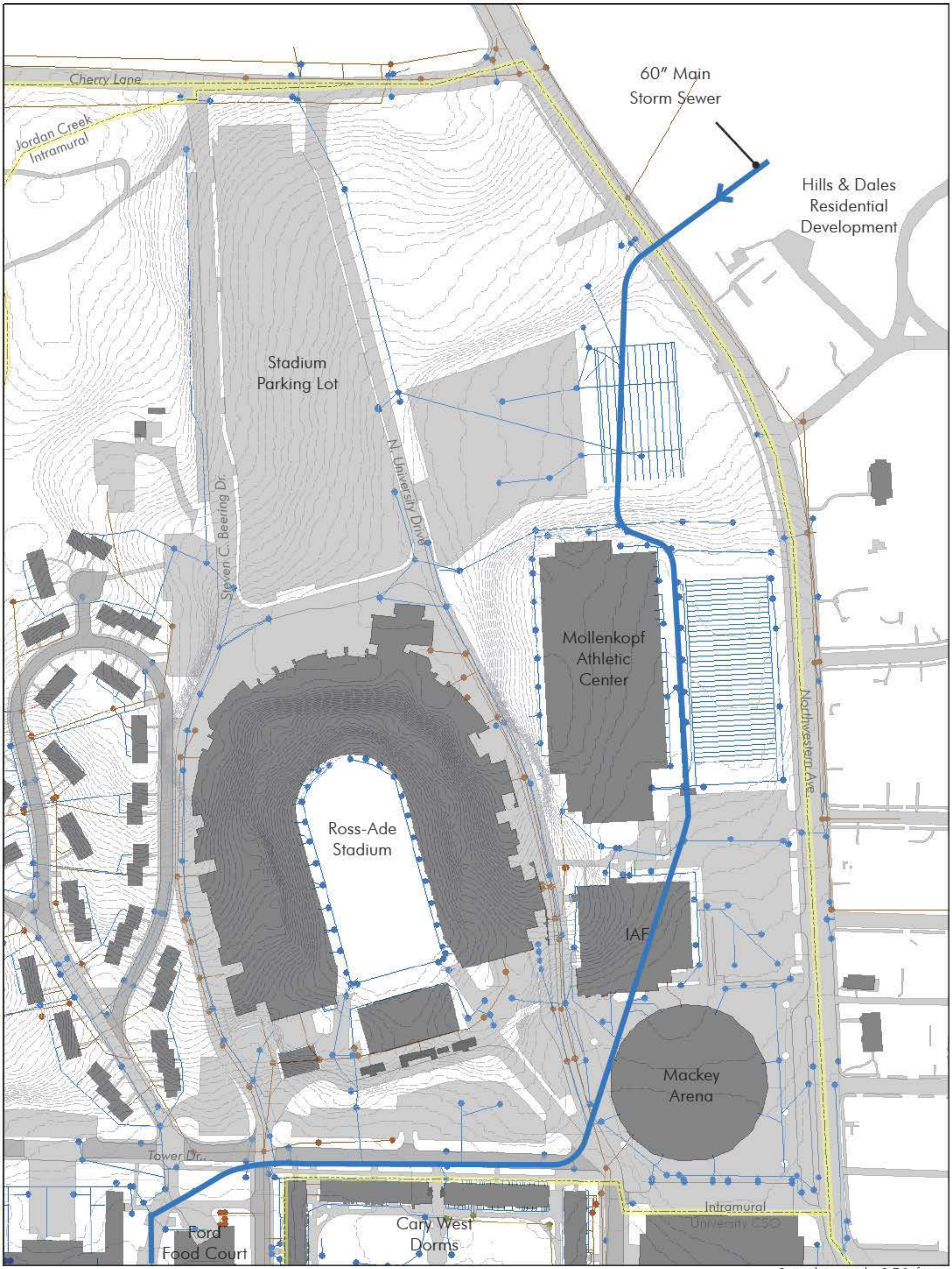
Chapter 5 - Case Studies

1. Mackey Arena
2. Ackerman Hills Golf Course
3. Tower Acres & Pickett Park
4. Third Street Intramural Gold Fields
5. Agricultural Mall
6. Campus Core
7. Harrison Pond Pollution Prevention
8. Coal Storage Area



1 inch equals 250 feet

Mackey Arena Redevelopment
Master Plan in Action

Overview of issues:

The Mackey Arena Redevelopment Project presented an excellent opportunity to capture stormwater from the large impervious areas surrounding the Stadium and Mollenkopf Intercollegiate Athletic Facility. The site redevelopment consisted of additional parking facilities and the construction of two new athletic fields north of the Mollenkopf building. Additional phasing of this project will incorporate pretreatment of stormwater before infiltration with bioswales in the parking lots and tree trenches along roads by Ross-Ade Stadium. Capture, treatment and infiltration of runoff generated by this large expanse of hardscape will make a sizable impact in reducing the volume of runoff conveyed to the University Storm Sewer System, particularly the 60-inch main stormwater trunk located east of Mollenkopf and flowing south.

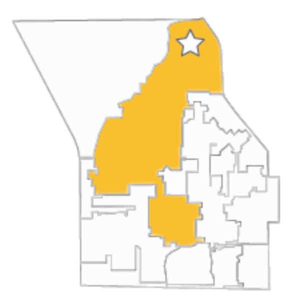
Storm Sewer Main

Sub-shed Boundary

Existing Sanitary Sewer

Existing Storm Sewer

1' Contour

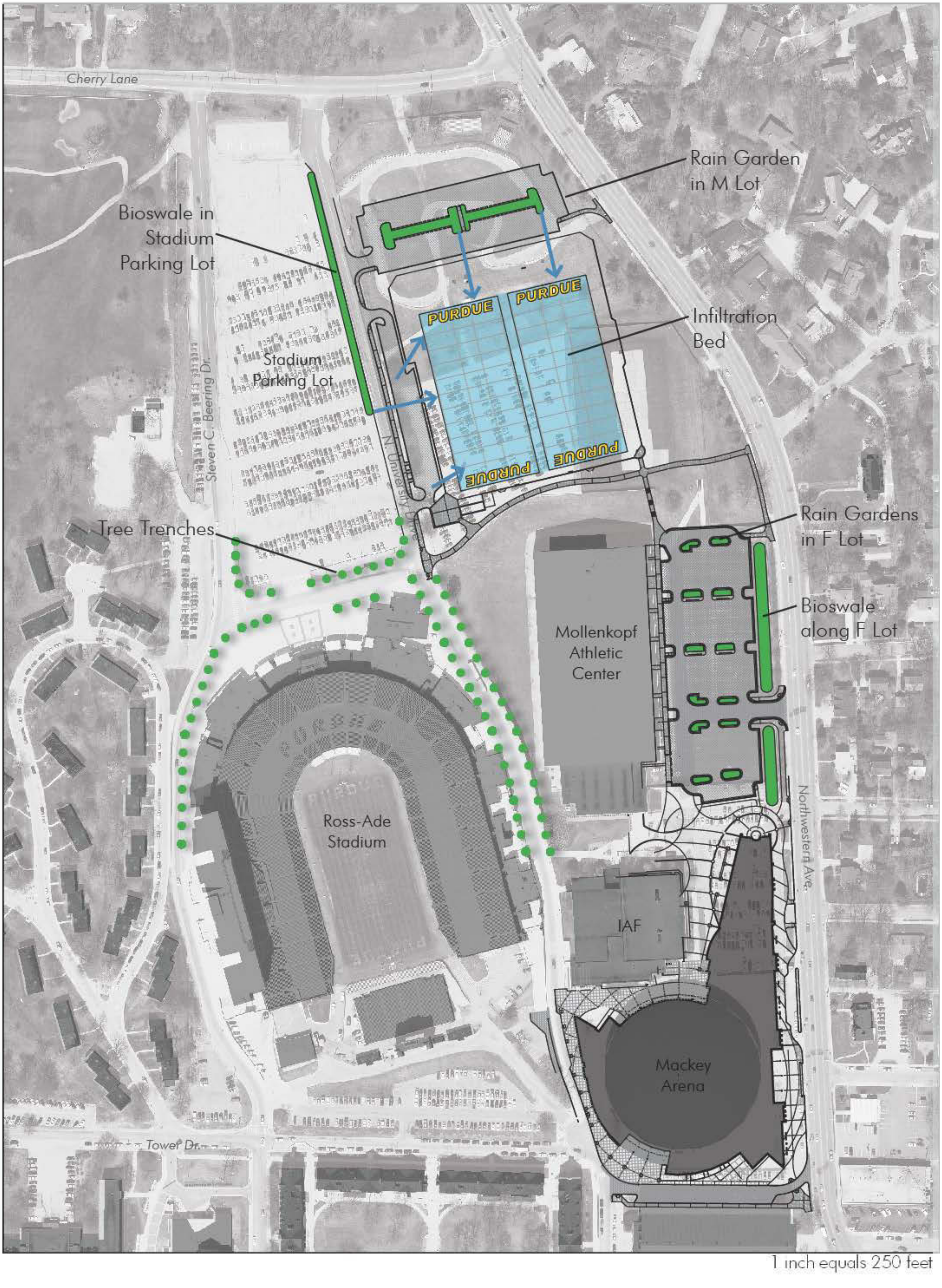


Drainage Area: Intramural

Existing Conditions:

A historic creek sourced from the Hills and Dales Neighborhood is currently drained within a 60-inch Storm Sewer Pipe located to the east of Mollenkopf. This piped creek flows south, picking up additional stormwater flow from the highly impervious campus core within the Intramural drainage basin to Harrison Pond. The Stadium drainage contributes significant stormwater flows in the 60-inch Storm Sewer trunk. In fact, several areas downstream of the Stadium experience frequent flooding due to high volume flashy flows within the 60-inch pipe. Two high priority flood locations include Cary Quadrangle West and the Ford Dining Court Loading Dock near the intersection of Tower Drive and Steven Beering Drive. Stormwater measures incorporated in the Mackey redesign will help to alleviate these problems. It should be noted however, that the Hills & Dales neighborhood is a contributing factor and changes within that development, beyond the University's control, will continue to exert pressure on the system down stream/storm sewer.

Stadium parking lot – The stadium parking lot located north and west of the Mackey expansion area, is the largest piece of contiguous paved surface on the Purdue campus besides the airport. With an approximate drainage area of 10.9 acres, the demand for parking at this location will only increase with the expansion of the Mackey Sports Center, and more impervious surface parking is being constructed. Surface drainage is generally to the southeast corner of lot, and new pervious pavement has been installed in a parking strip along the west side of Steven Beering Drive. The lot is heavily used for both sporting events and park & ride commuters. Stormwater management for this area is currently being incorporated into the new construction with infiltration beds under the new practice fields. A bioswale to run along N. University Drive is in design for the second phase of construction and will connect to the infiltration beds. Captured runoff from the Mollenkopf Athletic Center roof could be re-used for irrigation or infiltrated to recharge groundwater.



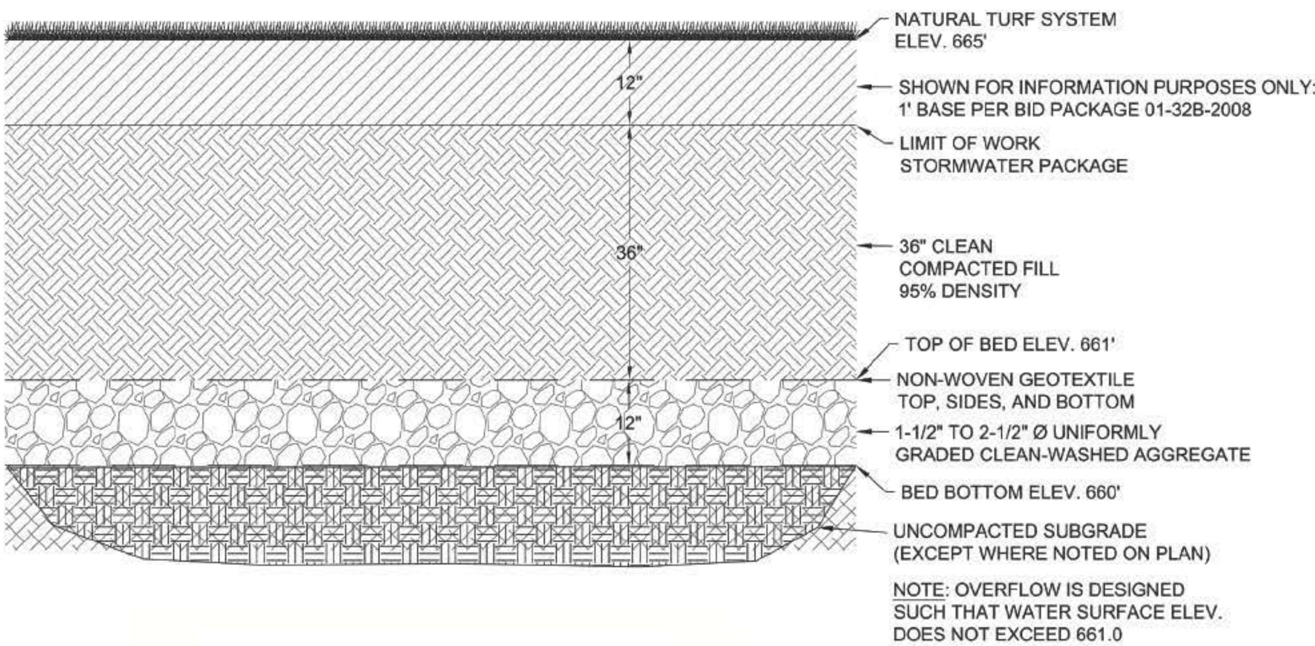
1 inch equals 250 feet

Design Considerations:

- Water quality is a consideration as the area has a high application of sand and salt as well as non-point source pollution from autos.
- Public events such as tailgating.

BMP Options Realized:

Infiltration Bed below New Practice fields – Runoff from the 10.9-acre Stadium Parking Lot drainage area as well as the new practice field (5-acres), A Lot and overflow from new M Lot parking is stored and infiltrated by a large subsurface stone infiltration bed located under the new practice fields. 1 foot of uniformly graded, clean-washed aggregate lies roughly 4 feet below the ground surface. Outlet structures for the sub-surface beds allow them to "fill up" before overflow is discharged to the storm sewer to maximize capacity. This bed provides adequate capacity to store and infiltrate the 1-inch rainfall volume from the entire drainage area. The total volume reduction provided by the bed (without including infiltration during rainfall) for a 1-inch storm is estimated at 45,917 ft^3 or 1.05 ac-ft (343,459 gallons).



Section through Infiltration Bed under Natural Turf Practice Field

Rain Water Harvesting System – a rainwater harvesting system, including cistern, could be located in the southwest corner of the stadium parking lot or within the existing slope west-northwest of IAF. This system could capture all relevant stormwater including roof runoff from Mollenkopf for re-use to irrigate football practice fields and any other opportunities with no or minimal pumping equipment. Currently all existing fields are irrigated with groundwater provided by University wells. The rainwater harvesting system includes an irrigation system design to allow for a dual feed (alternating) of potable water and rain water from the cistern, reducing the need for potable water for irrigation.

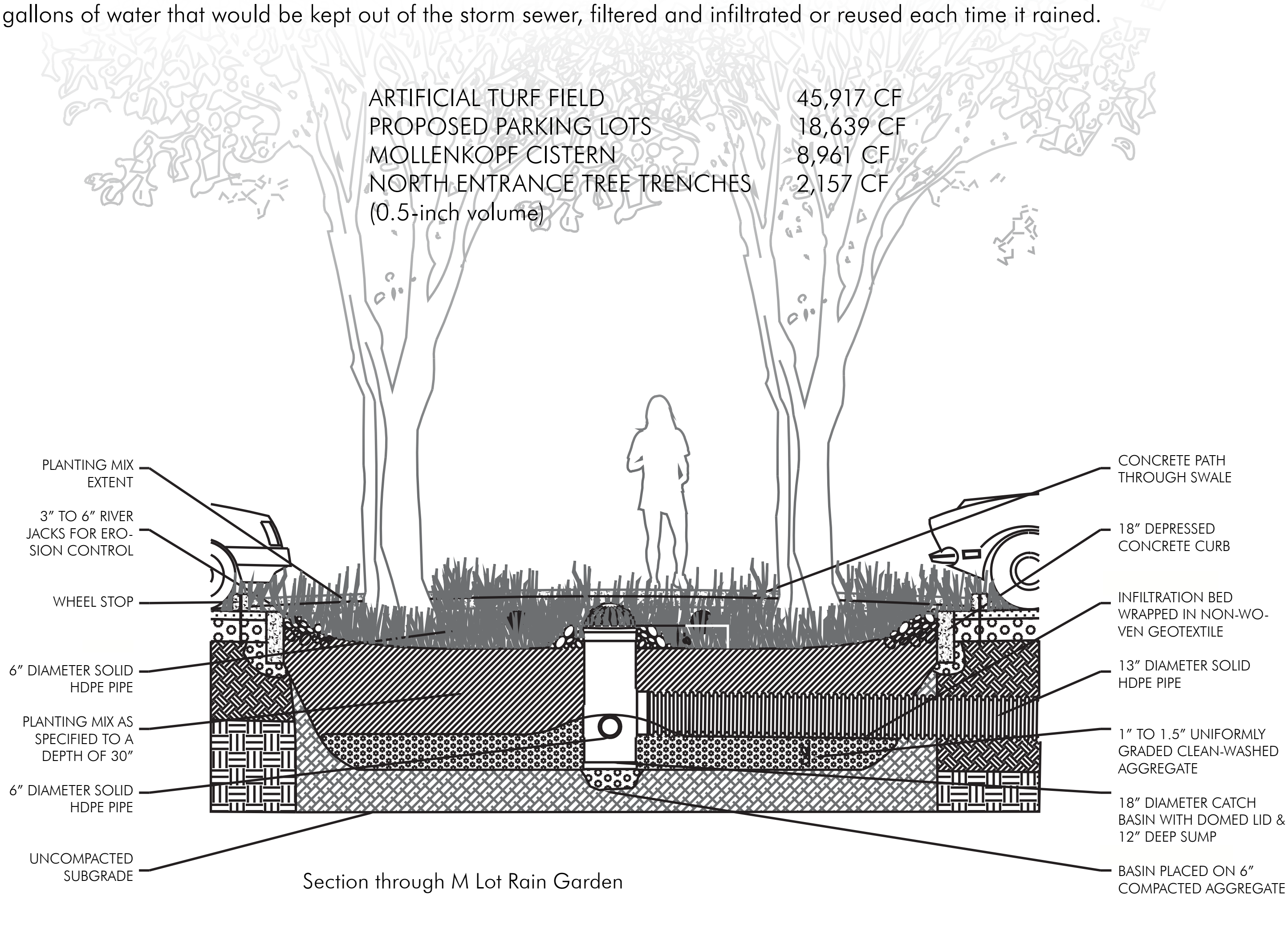
Tree Trenches at the North Stadium Entrance – The existing North Gate entrance to the football stadium is the prime egress and ingress location for this popular University Sports Facility. However, it is largely paved with little vegetation. Runoff from this area contributes to stormwater flow within the large 60-inch storm sewer trunk that contributes to flooding further south. This area provides an opportunity to demonstrate retrofit methods that incorporate greening and aesthetic enhancement with stormwater volume control by installing a series of stormwater tree trenches along the entrance area. To maximize congregation and circulation space the tree trenches are finished with porous pavers to allow surface runoff collection and pedestrian traffic. The Tree Trenches will also serve to improve water quality before runoff enters the infiltration beds under the fields.

Rain Gardens and Bioswales – The Mackey project includes rain gardens within parking islands of F & M Lot as well as a large bioswale along the eastern edge of Stadium Parking Lot. The current rain garden design utilizes curb cuts and rain gardens with specialized planting media to convey surface runoff from the parking lots to subsurface infiltration beds. Both the rain garden systems and the subsurface storage beds are under-drained so that the system will not fill up. Outlet structures in the M lot rain garden allow for unimpeded overflow to the infiltration beds under the practice field. The bioswale is designed to capture the entire F Lot area with additional runoff from Cherry Lane. Again, these measures are important to improve water quality from road and parking lot runoff prior to infiltration.

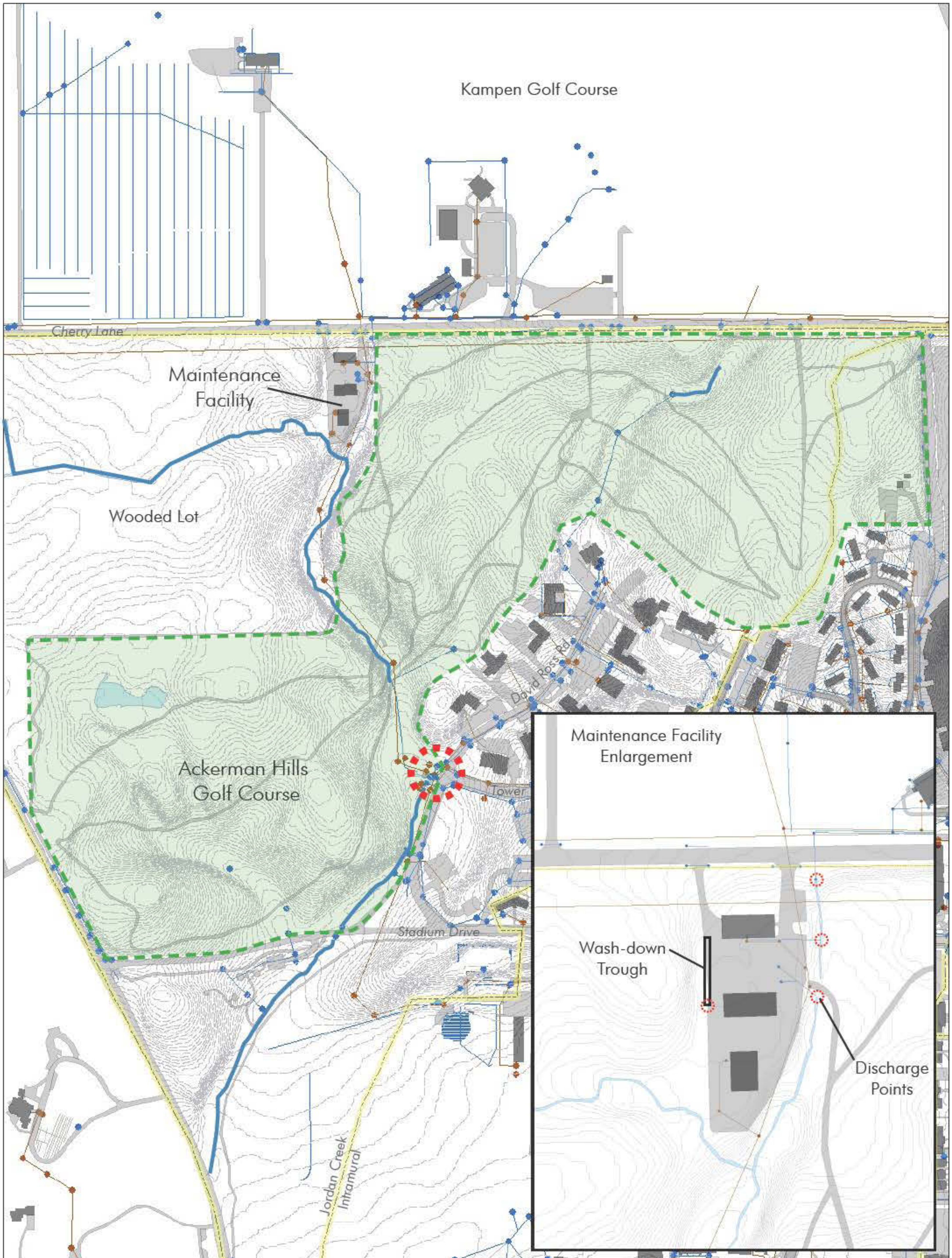
Benefits:

The capture and reuse or infiltration of stormwater runoff from the Stadium and Mackey Athletic Center Expansion Area will reduce the volume of flow of stormwater to the university storm sewer system. The total estimated potential volume reduction achieved during a 1-inch storm event by the above recommendations is provided below. Totalled, it is an estimated 566,080 gallons of water that would be kept out of the storm sewer, filtered and infiltrated or reused each time it rained.

ARTIFICIAL TURF FIELD	45,917 CF
PROPOSED PARKING LOTS	18,639 CF
MOLLENKOPF CISTERN	8,961 CF
NORTH ENTRANCE TREE TRENCHES (0.5-inch volume)	2,157 CF



Section through M Lot Rain Garden



1 inch equals 550 feet

Ackerman Hills Golf Course & Maintenance Area

Overview of issues:

Ackerman Hills Golf Course is a considerably large parcel of land in the upper portion of the Purdue Campus with the potential ability to mitigate large volumes of stormwater, both falling on the site and running through it from areas beyond the site study boundary. Best management practices can start at the maintenance facility and foster a consciousness that will carry throughout the course.

- Open Water Course
- Outlet/Discharge Point
- Golf Course Extents
- Sub-shed Boundary
- Existing Sanitary Sewer
- Existing Storm Sewer
- 1′ Contour

Drainage Area: Jordan Creek


Discolored Runoff From Ackerman Hills Golf Course

Existing Conditions:

Ackerman Hills Golf Course is approximately 110 acres located in the NW corner of the campus, about 10% of the entire study area. Not only does it receive the water that falls directly on site, it accepts water that is piped to it from Cherry Lane and McCormick Road, from the Kampen Golf Course and its facilities directly to the north, as well as surface drainage from the field and wooded lot to the west. Drainage pathways are alternately exposed and submerged throughout the golf course which ultimately discharges to an unnamed tributary running along the SE side, parallel to David Ross Road. It eventually reaches Pickett Park where erosion problems are observed. A small portion of surface runoff is piped under Stadium Drive and discharged in the tributary by Pickett Park, where water discoloration can be observed. Seeps were noted along the edge where Ackerman meets Steven Beering Drive.

The Golf Course is an highly maintained landscape where the intense use of fertilizers is part of the routine maintenance procedure. Fertilizer is used on both the greens and fairways (approximately 3 pounds per 1,000 square feet per on the greens and 4 pounds per 1,000 square feet per year on the fairways). These fertilizers contain soluble nitrogen that can move through the lawns into the groundwater, as well as discharge directly to surface water. This can result in high concentrations of nitrogen in ground and surface waters, rivaling that which can be expected from agricultural land uses and often much higher than residential land uses. Vegetated measures that intercept runoff, trap sediments, and uptake soluble nutrients can significantly reduce the discharge of these pollutants, especially along the sides of streams and small flow paths. The implementation of streamside vegetated buffers along tributaries will both slow the discharge of runoff from the golf course and reduce the pollutant discharge.


Shotcrete Stabilization Of Stream Bank - Cherry Lane In The Distance

A second component of the golf course is the maintenance area for Ackerman Hills, located in the far NW corner of the course. To the east of the maintenance area's parking lot is an open channel where runoff from the Kampen course and portions of Cherry Lane are discharged. Shotcrete has been applied on either side of the channel to stabilize the banks. Drainage from the maintenance area parking lot and northern most building are discharged into this channel as well, carrying with it any non-point source pollutants from vehicles, equipment and spills or improper storage of fertilizer and pesticide/herbicide etc. To the far west of the maintenance area is the equipment wash-down area. A long cement trough that runs half the length of the maintenance area was installed to prevent erosion. Currently, it carries the wash water and discharges it into the adjacent woods. Algal growth was observed in puddles of water by the forest edge. Installation of a vegetated system to treat this runoff preceded by a screening system and discharging to an infiltration bed, will alleviate this problem.


Discharge Pipe from Maintenance Facility Parking Lot

Fertilizers contribute nutrient loads to surface water via phosphorous attached to colloidal particles as well as in solutions (nitrate). Nutrient loading contributes to water quality degradation in surface water by accelerating eutrophication which can lead to anaerobic conditions. Though runoff from the Ackerman Hills Golf Course has not been tested, it is assumed that it contains nutrients which enter Jordan Creek and ultimately the Wabash River.

Golf Maintenance Wash Down Area

Algal Growth by Terminus of Wash Down Trough

Design Considerations:

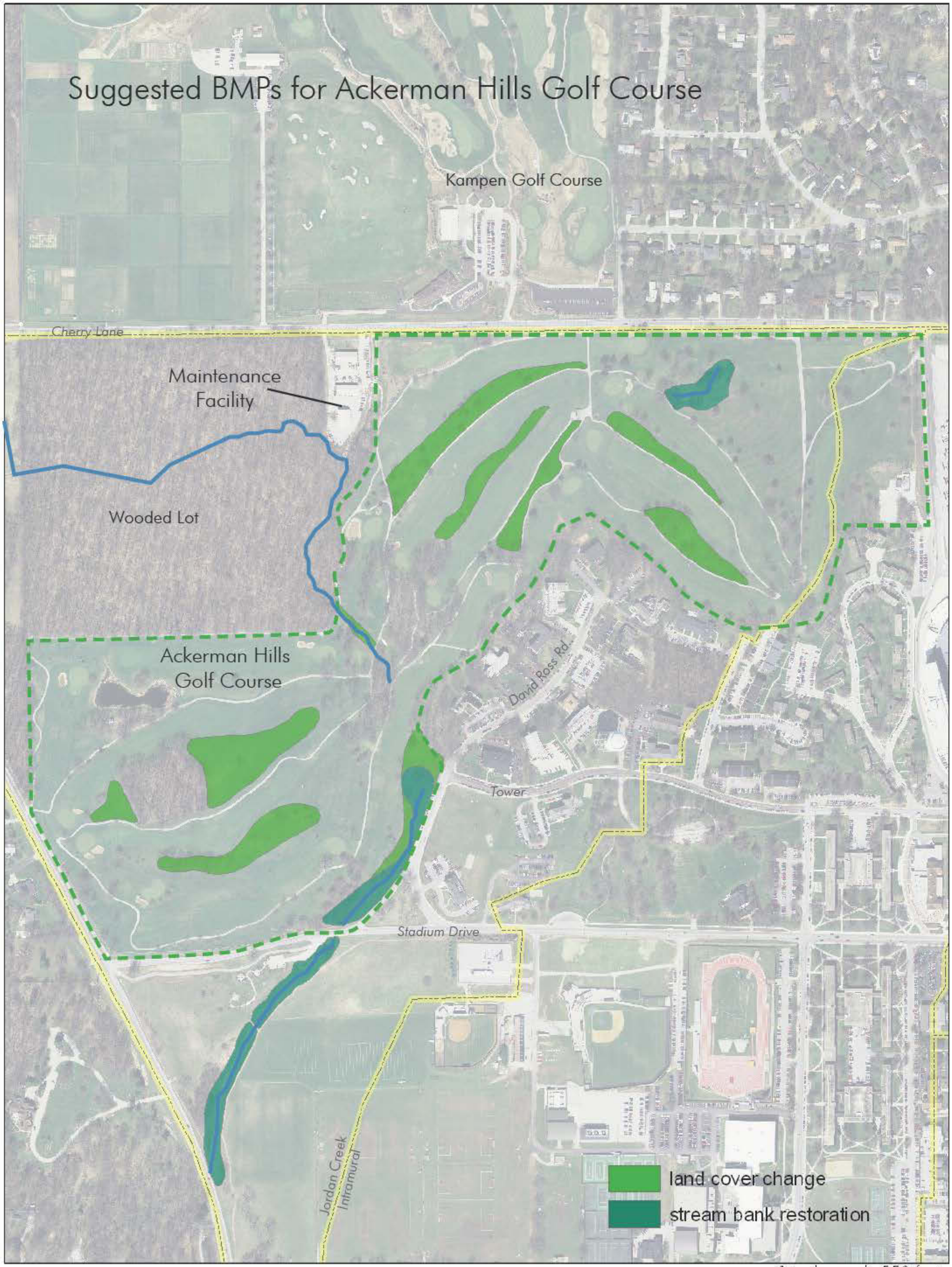
- View lines for golfers – blockage of fairways and other obstructions
- Nutrient loads, their ultimate destination and impact, and ability to reduce usage.
- Location of seeps for potential vegetated buffers zone creation.

BMP Options:

- Convert non-essential green and fairway to different vegetated cover types
- Provide native vegetated buffer along open water courses and at seeps and wet locations.
- Pretreat runoff from wash-down area and maintenance parking lot with wetlands treatment/infiltration system and remove direct discharge to stream.

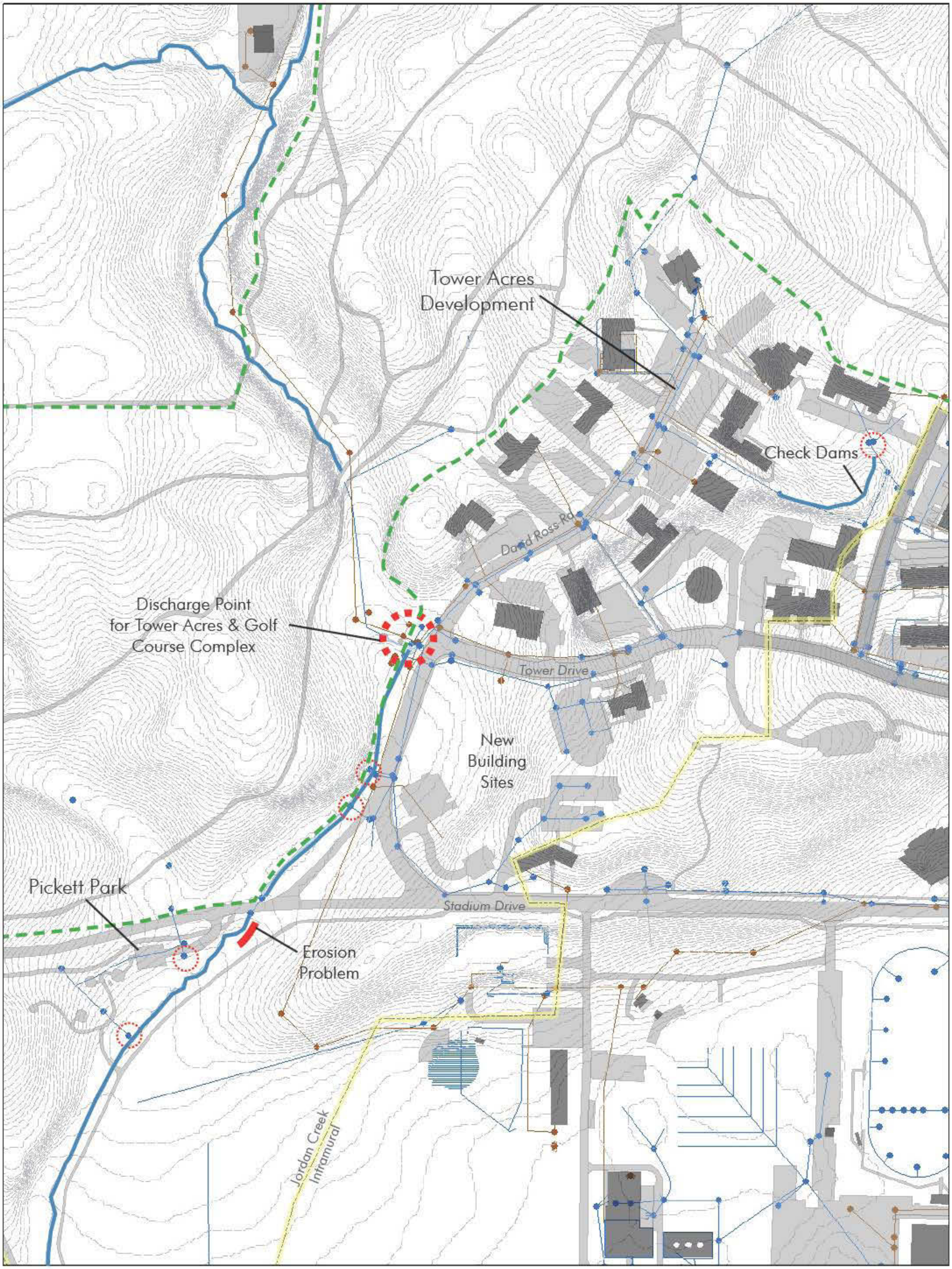
Benefits:

- Vegetated buffers along stream channels and drainage ditches allow for uptake of excess nutrients from fertilizer runoff and help to stabilize banks, while trapping sediments.
- Enhancing/changing the vegetative cover will lessen dependence on irrigation, pesticides, herbicides and fertilizers and reduce maintenance once established.
- Adding and transitioning vegetation to native plants that support habitat will help obtain Audubon certification. The proximity to the wooded lot to the west is an opportunity, especially with its eastern edge facing the course. Eastern edges of forest stands adjacent to open meadow areas are important for bird populations. The forest provides shelter for the birds and the meadow (golf course) a source of food with bug populations. Eastern edges warm up earlier in the morning sun and so do the bugs. So the early bird really does get… in this case, the bug.



1 inch equals 550 feet

Equipment wash-down trough at golf maintenance area.



Tower Acres
Development
Check Dams
David Ross Rd
Discharge Point
for Tower Acres & Golf
Course Complex
Tower Drive
New
Building
Sites
Pickett Park
Stadium Drive
Erosion
Problem
Jordan Creek
Intramural

Tower Acres - Unnamed Tributary - Pickett Park - and Beyond

Overview of issues:

Compounding stormwater management issues from upland sources are manifesting in an unnamed tributary that runs along the west side of David Ross Road. This tributary, one of the only remaining natural water courses on the Purdue Campus, crosses Stadium Drive into Pickett Memorial Park where discolored runoff from the golf course is discharged and severe erosion problems exist at the culvert outfall and along the banks of the stream as it traverses through the park. The tributary continues through the west side of the Intramural Gold Fields and eventually enters the Horticulture Park where it continues to cause problems outside of the study boundary.

This last remaining surface water stream within Purdue University is a potential amenity that could be a celebrated resource on Purdue's campus. The problems within this tributary are a symptom of a lack of stormwater management within upland drainage areas, and therefore, the tributary's localized problems at Pickett Park cannot be addressed only where they appear but must also be resolved at their source. Tower Acres, the Birck Boilermaker Golf Complex and portions of West Lafayette residential developments drain to this tributary, interventions within them that reduce the volume and rate of stormwater runoff have the ability to make a positive impact. Following implementation of upstream volume control measures, streambank restoration of the Pickett Park unnamed tributary has the ability to both restore natural floodplain functions within the Park and provide a naturalized aesthetic enhancement.

Open Water Course

Outlet/Discharge Point

Golf Course Extents

Sub-shed Boundary

Existing Sanitary Sewer

Existing Storm Sewer

1' Contour

Drainage Area: Jordan Creek.

*This tributary accepts additional drainage from above Cherry Lane located beyond our study area.

Discharge Pipe in Wooded Lot at the top of Tower Acres Development

Ponding around the Base of Trees in Tower Acres

Drain Inlet in Wooded Lot at the top of Tower Acres

Existing Conditions:

Continued development in the drainage area is increasing the stormwater volume and amount of pollutants discharged into the unnamed tributary. Both the Birck Boilermaker Golf Complex and Tower Acres development are contributing to the problem.

Tower Acres – Recent construction in Tower Acres has added impervious surface which is exacerbating existing runoff problems. Surface runoff from the developed area is collected in a 36-inch storm sewer located under David Ross Road. This discharges to the tributary at the intersection of David Ross and Tower Drive. Within the development itself, surface drainage through the wooded lot to the east of David Ross Drive is causing severe erosion problems. Inlets to the large 21" storm pipe running under this area are blocked due to sediment deposition. Saturated conditions and surface ponding of runoff has been observed and changes in the hydrologic conditions in the woodland area will inevitably cause changes in the plant composition. Tree loss is a safety concern as the woodland is actively used as a pedestrian pathway and could cause damage to adjacent buildings. The continued erosion poses environmental concerns as sediment laden runoff from this area discharges to the sewer system connected to the unnamed tributary within Pickett Park. A series of check dams north of Zeta Psi is currently under construction to slow the velocity of runoff and reduce the flashiness of the runoff events. However, further vegetative enhancement and ground cover establishment is necessary to reduce erosion and provide soil stabilization.

Pickett Park – Additionally the tributary also accepts surface and piped drainage from Birck Boilermaker Golf Complex and a small portion of the Intramural Gold Fields, making nutrient loading a concern. Improvements to the open drainage pathways within Ackerman Hills will help to improve water quality and volume control as discussed in the Ackerman Hills section of this report. This strategy can be extended to other reaches of the tributary, once stormwater controls upland are established.

Other Considerations:

- The stormwater contribution from the Birck Boilermaker Golf Complex and beyond should be fully understood.
- Maintenance practices/budgets for these areas
- Stream bed material will dictate the ability to create pool and riffle sequences and how they are made. Streams with sand beds typically do not develop this morphology and tend to be much more dynamic, so a better understanding of base material is required.

Extent of Flooding Marked by Deposition

Undercutting of Bank at Pickett Park Entrance

BMP Options:

Tower Acres - Goal is to infiltrate stormwater and if that's not a possibility, to delay and it release slowly.

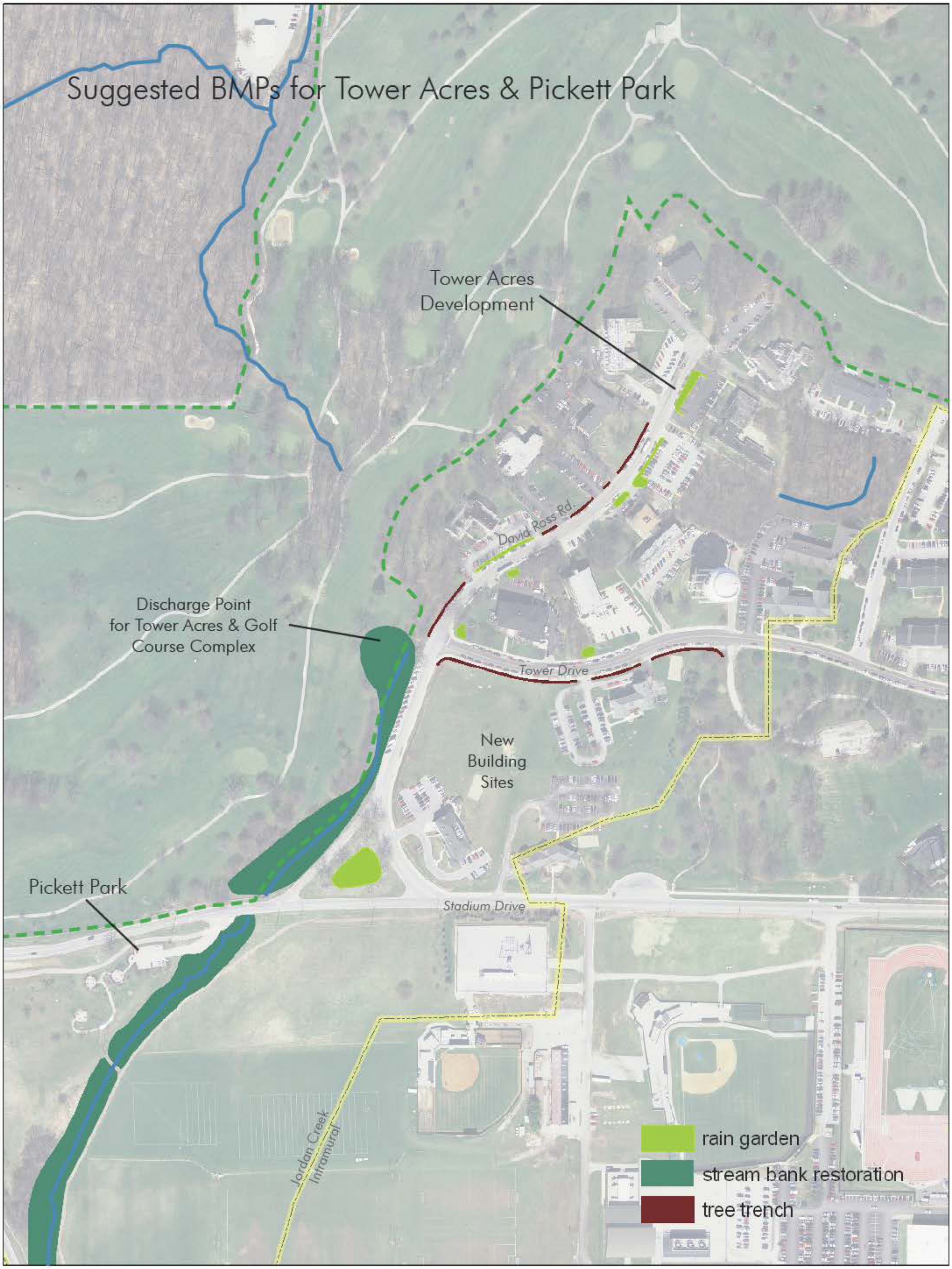
1. David Ross stormwater streetscape design– Tree trenches, bump outs, pervious pavement with infiltration beds
2. Parking lot retrofits with rain gardens or pervious pavement and infiltration beds
3. Disconnect external roof leaders that connect to sewers into a vegetated or infiltration system that overflows to the existing storm sewer

Pickett Park – upland attenuation must be dealt with first before any significant investment is put toward upgrading the hydrology of the park. For example, fortifying the eroding bank by the bridge will only push the erosion/scour problem slightly downstream to the other side of the bank if nothing upstream is done to attenuate the flow and volume discharging to the park. Therefore, first priorities should be placed on Tower Acres interventions. However, since the stream within the Park has begun to "cut down" and is disconnected from the floodplain, regrading to re-establish the flood plain connection and establish a vegetated buffer between the lawn and the stream will help to alleviate the current erosion situation and attenuate flow velocities.

1. Native vegetated plantings along stream channels and drainage ditch along Stadium Drive
2. Pool and riffle sequences in stream channel and streambank restoration
3. Velocity attenuation of discharge locations
4. Floodplain restoration and regrading where banks are severely undercut

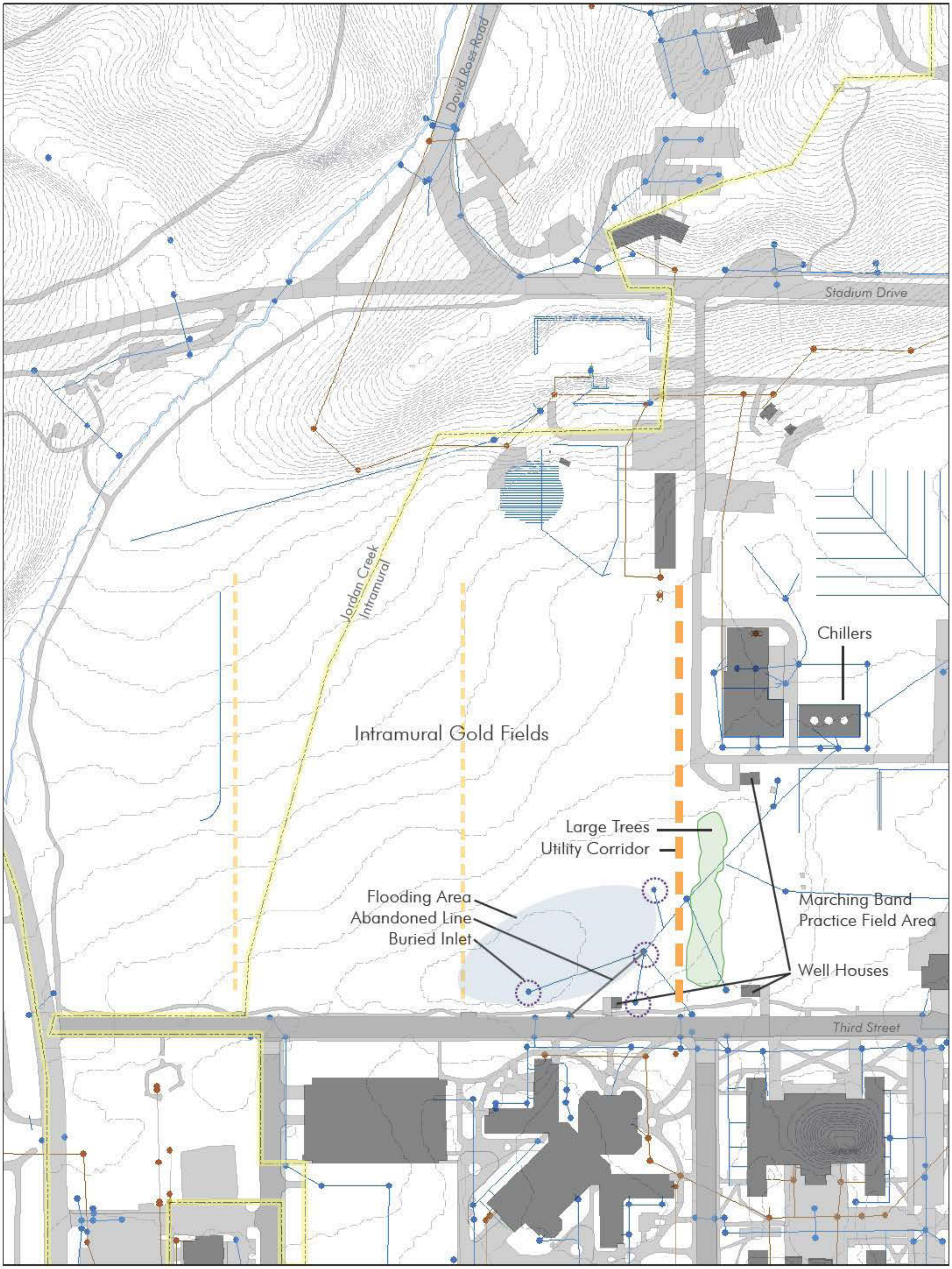
Benefits:

Vegetated buffers with native plants allow for uptake of excess nutrients from fertilizer, filter runoff and help to stabilize banks. Pool and riffle helps to aerate and allow for deposition of particulate matter within the water. Floodplains provide out of stream storage during large storm events, preventing flood damage further downstream.



Suggested BMPs for Tower Acres & Pickett Park
Tower Acres
Development
David Ross Rd.
Discharge Point
for Tower Acres & Golf
Course Complex
Tower Drive
New
Building
Sites
Pickett Park
Stadium Drive
Jordan Creek
Intramural
rain garden
stream bank restoration
tree trench

Unnamed Tributary in Pickett Park

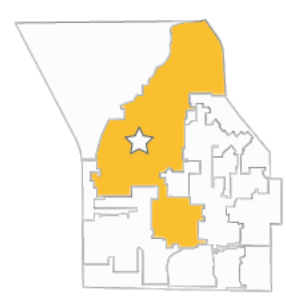

David Ross Road
Stadium Drive
Jordan Creek Intramural
Intramural Gold Fields
Chillers
Large Trees
Utility Corridor
Flooding Area
Abandoned Line
Buried Inlet
Marching Band Practice Field Area
Well Houses
Third Street

Third Street Intramural Gold Fields

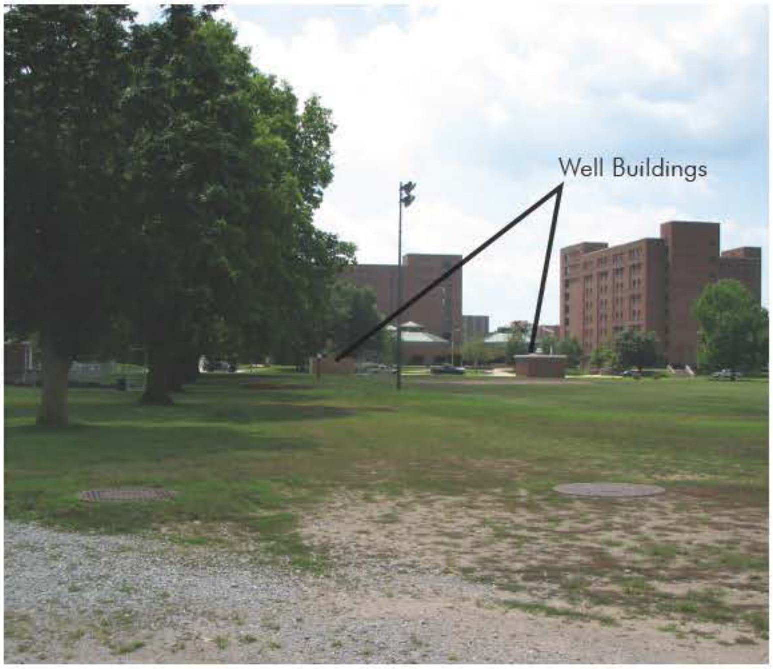
Overview of issues:

Disconnected & buried drainage infrastructure leaves the area to the SE corner of the Intramural Gold Fields prone to reoccurring flooding problems. Stormwater infiltration at that location has raised concern for aquifer contamination by soluble pollutants due to existing well heads & recharge areas found in the same vicinity. Pretreatment before infiltration or storage and reuse are both applicable means of dealing with the flooding. Reconnecting the drainage system would only push the problem down to another location.

Important Tree Massing
Utility Corridor
Electrical Trough
Buried Inlet
Sub-shed Boundary
Existing Sanitary Sewer
Existing Storm Sewer
1′ Contour



Drainage Area: Intramural



Large Trees Bordering the East of the Intramural Golf Fields. Looking South Down the Utility Corridor with Well Buildings in the Distance

Existing Conditions:

The Intramural Gold Fields, are primarily designated for specific sports programs. This relatively flat expanse of open space is close to the campus core and is one of the few large multi-purposed spaces the campus has. It drains to the SE corner where flooding regularly occurs. Existing drainage infrastructure is present but not connected. Storm sewer inlets are buried to prevent tripping hazards on play fields or are indicated as "abandoned" from the sewer lines running under Third Street. The fields are also used for game day parking which causes compaction and requires increased maintenance of the fields, including possible intensive fertilization, than would otherwise be normal.

The fields are to remain as open space and are designated as an aquifer recharge zone. Several well heads are located at the south edge of the field and supply water to the campus. These are protected by a 100' sanitary set back in which no infiltration is allowed by law. Pretreatment is required in well head protection areas before infiltration can occur.

There are a few existing structures to the NE by Lambert Field that have chillers which may provide an opportunity to intercept the condensate for use in irrigation or other reuse applications. This opportunity requires further study relating to the chiller design and the chillers don't currently contribute to the flooding on the fields. Additionally, well house discharge is periodically conveyed to storm sewers. This discharge could be conveyed to a reuse systems, rather that discharging offsite.

Large trees are situated around the southern half of the perimeter, with those running along the east side being especially impressive as well as good providers of much needed shade proximal to sports fields. Just to the west of those impressive trees, a utility corridor composed of primarily water and electrical conduits runs north and south. A new marching band practice field with a porous asphalt strip along the perimeter was installed where the tennis courts were located. A portion of the tennis courts remain to the north of the new marching band field.

Design Considerations:

- Application of fertilizers/pesticides/herbicides with soluble pollutants, and subsequent contamination of the aquifer by draw down pumping from adjacent wells.
- Consider pretreatment of runoff before infiltration in this sensitive area, especially if runoff from other surfaces is captured.
- Protection of significant trees

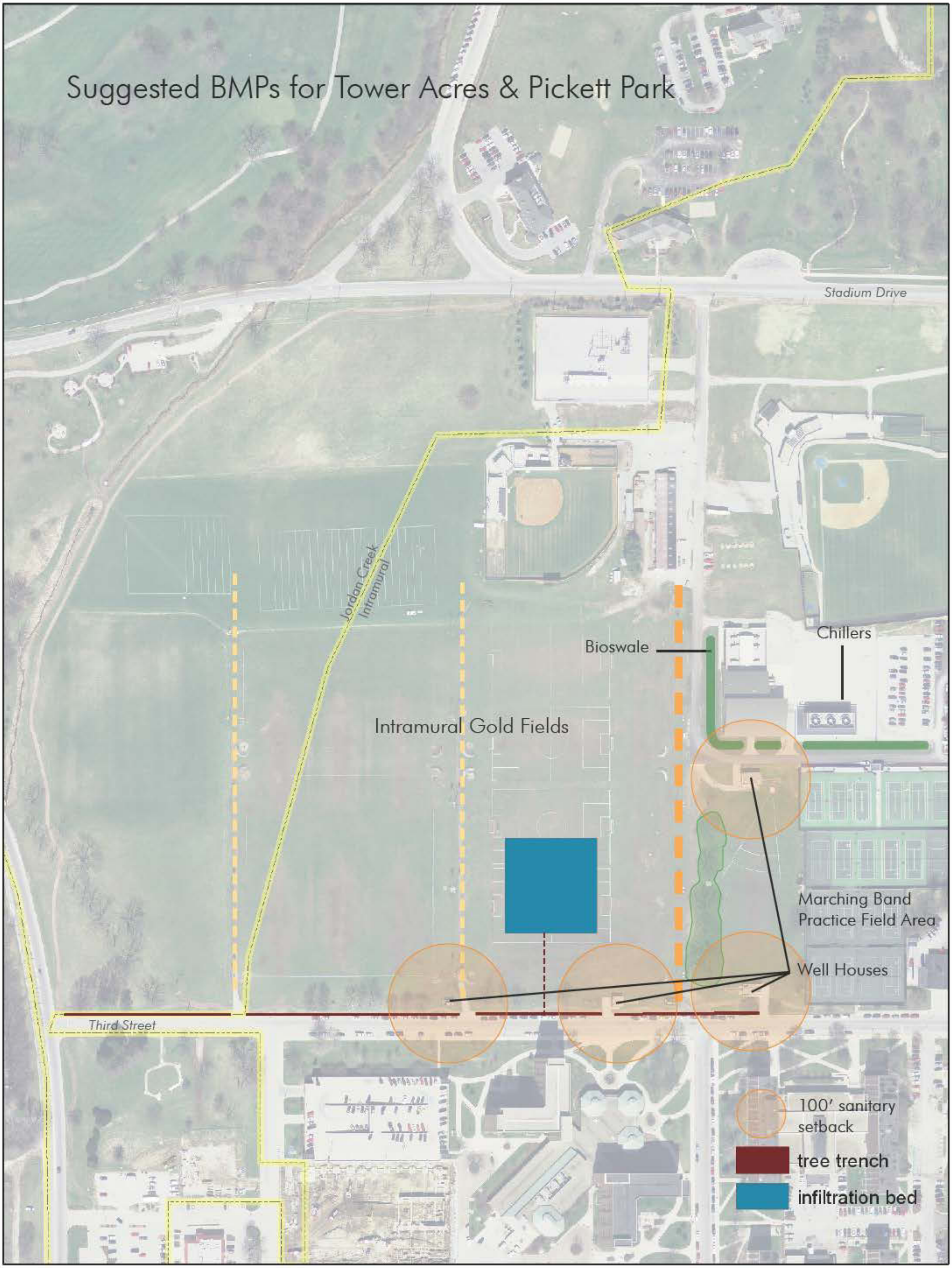
BMP Options:

Reconnecting the drainage system to alleviate flooding would only push the problem downstream to another location. Runoff from the fields should be managed on-site through the use of vegetative and infiltration BMPs, while respecting the 100′ sanitary zone. A long-term field management plan should be developed to reduce fertilizer and herbicide/pesticide use due to the proximity to the potable water wells.

1. Infiltration bed with pretreatment bioswales (try not to break the space apart)
2. Lined tree trenches along Third Street to pretreat and convey stormwater to infiltration bed
3. Very specific management guidelines and regulations for fertilizers & pesticide/herbicide application
4. Cistern to capture condensate from adjacent chillers and discharge from well houses for field irrigation or release into bioswale next to building.

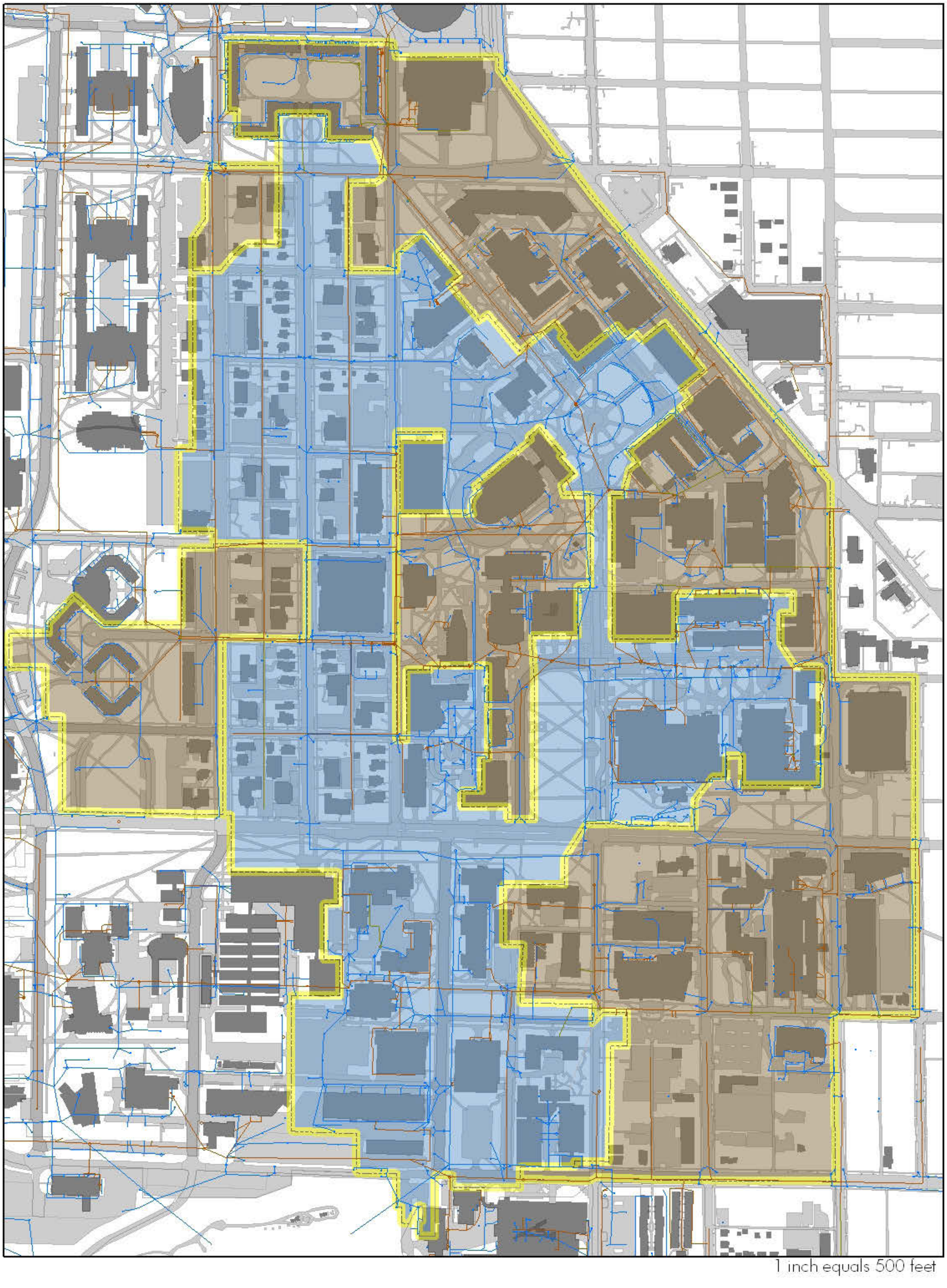
Benefits:

- Reduced flooding of fields
- Enhanced landscape features can provide shading for sports field observers and enhance aesthetics
- Increase pollution prevention by better managing chemical use for field maintenance
- Reduce potable water use for irrigation



Suggested BMPs for Tower Acres & Pickett Park
Stadium Drive
Jordan Creek Intramural
Bioswale
Chillers
Intramural Gold Fields
Marching Band Practice Field Area
Well Houses
Third Street
100' sanitary setback
tree trench
infiltration bed

Area next to Chiller Building



1 inch equals 500 feet

Campus Core

Overview of issues:

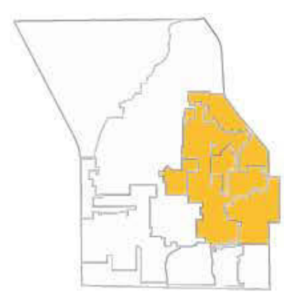
The campus core consists of two drainage areas; University and University CSO. These are the top 2 most impervious drainage areas on the campus 73.6% and 72.1% respectively. While the majority of the stormwater is piped directly to Harrison Pond, there is some amount of stormwater as well as cooling water that is discharged into the combined sewer system.

University CSO Sub-shed

University Sub-shed

Existing Sanitary Sewer

Existing Storm Sewer



Drainage Area: University and University CSO areas combined

Irrigation lines being installed with external roof leader (red arrow) in the background. Perfect location for a cistern.

Trench drain in sidewalk next to Grant Street, by Purdue Memorial Union. Could be incorporated into a sub-surface continuous tree trench with hardscape on top.

Curb-less, continuous, tree pit in campus core parking lot. Could be design for more storage capacity if grading allows.

Existing Conditions:

The Campus Core is characterized by large academic buildings and residence halls, wide pedestrian walkways and malls, expansive tree lawns and high maintenance landscape areas, major street thoroughfares as well as numerous surface-parking areas. Due to the number of highly manicured lawns and planting areas, seasonal irrigation of vegetated areas is prevalent. Irrigation water is provided by potable water wells.

This highly urbanized area, with it's system of underground and surface utility infrastructure, presents a challenge in terms of stormwater management. However, at the same time, the campus core provides many opportunities to integrate stormwater management practices into the built environment - to manage runoff close to where it is generated.

Design Considerations:

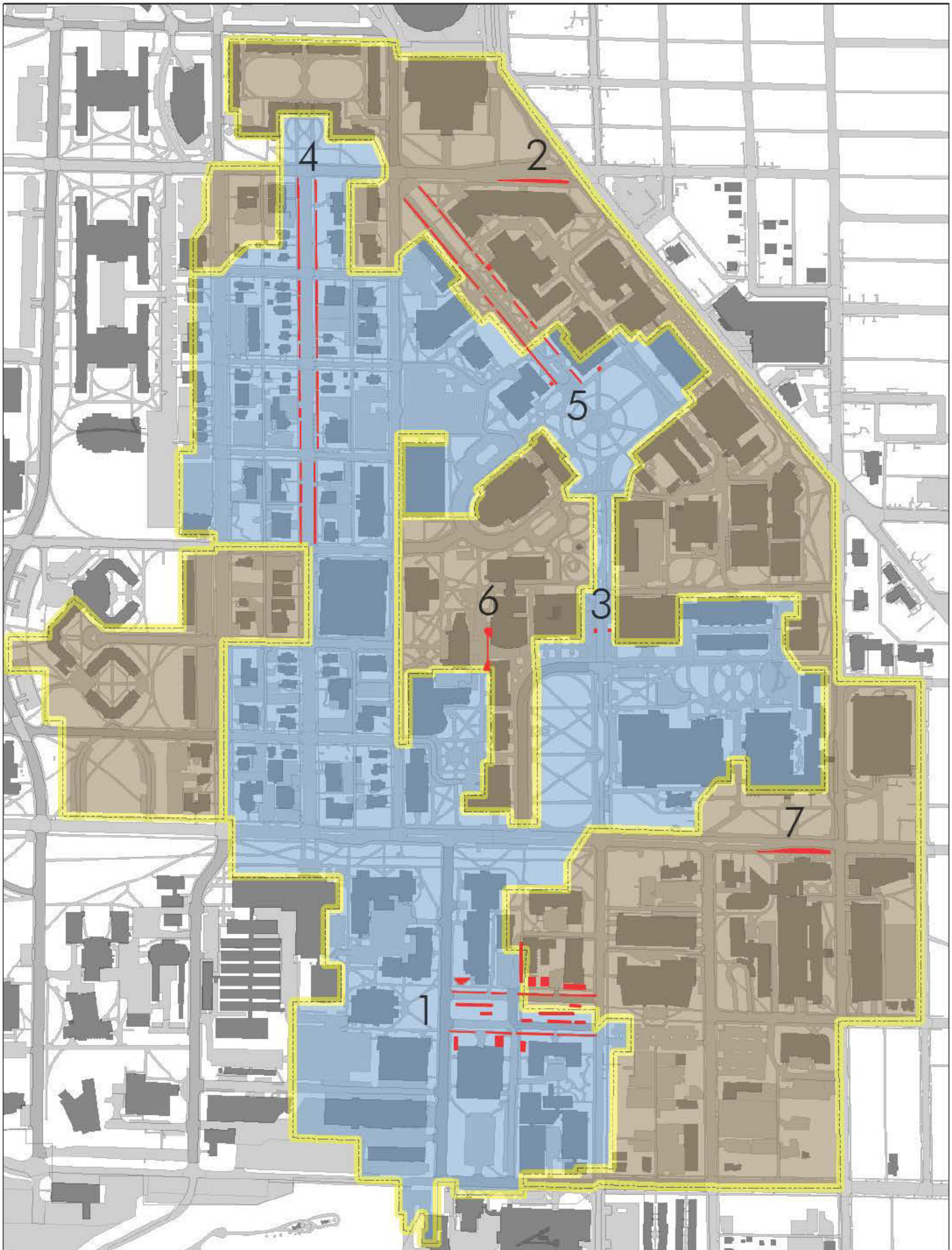
Due to the dense development in the Campus Core, space is generally not available for very large BMPs, and conflicts, such as underground utilities and building foundations, must be carefully considered with each design or avoided altogether. The character of the Campus Core requires that stormwater interventions be interspersed within developed areas where feasible and redevelopment projects must be used as opportunities to "fit in" stormwater management measures.

The Campus Core is characterized by highly maintained landscapes. Therefore, rain gardens, bioswales, and tree trenches should match the character of the surrounding landscape and will likely be more formal. The Campus Core presents an opportunity to integrate stormwater measures for dual use – rain gardens in existing landscapes, subsurface infiltration under lawn areas, bioretention and tree trenches in streetscapes.

BMP Options:

There are numerous BMP options within the Campus Core, some of which have been documented in separate case studies. Immediate opportunities have been described in Chapter 4.3 and listed below:

1. Agricultural Mall
2. Stadium Avenue Bump-out at Neil Armstrong Building
3. Crossing the Tracks
4. The "Island"
5. Stadium Mall
6. Mathematical Sciences Building
7. State & Grant Bump-out



1 inch equals 500 feet

1 inch equals 150 feet

Agricultural Mall

Overview of issues:

Plans for the redesign of the Agricultural Mall are currently underway and will include the conversion of vehicular roads into a pedestrian mall. Consideration of stormwater elements, as well as surrounding academic program philosophies, will help to guide the design and should be incorporated in the beginning phases of design. Due to the high number of utilities running underneath The Agricultural Mall designing for stormwater will be a challenge, but if done well, can help to demonstrate how innovative stormwater management techniques can be implemented within the tightly built-out campus core areas.

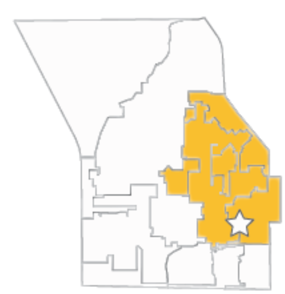
Storm Sewer Main

Sub-shed Boundary

Existing Sanitary Sewer

Existing Storm Sewer

1' Contour



Drainage Area: University and University CSO at the NE corner of the site.

Existing Conditions:

The Agricultural Mall is being redesigned as a central gathering space in order to create a more walkable/usable space for pedestrian circulation and for passive recreation by students. University Drive, Marsteller Street, and two roadways named Agricultural Mall bound the current open space. These two streets are currently used for vehicular traffic, provide some street parking and cover an area of 0.8 acres (34,700 ft2). Horticulture Drive separates the two grass islands in the center. The current plan is to convert the two Agricultural Mall roadways and parking areas into pedestrian walkways, eliminating most vehicular traffic by limiting it to emergency vehicles only.

There are two raised grass islands in the center of the mall that, due to their elevation and location over utilities, limits their applicability for stormwater elements. The other surfaces of the area generally slope to the south and east, while the storm sewers drain from the east to the west into a 66-inch pipe that ultimately discharges into Harrison Pond. The drainage area for the Agricultural Mall is approximately 4.2 acres.

Another area of concern near the Agricultural Mall is the alley adjacent to the Entomology Lab, which has a history of drainage problems above the large tunnel under this alley. Plans for this tunnel to be relined provide an opportunity to couple the work with stormwater infrastructure.

Several large buildings currently contribute significant volumes of runoff to the storm sewer system. The roof areas of the Entomology Lab (0.3 ac), Forestry Building (0.3 ac), and the Horticulture Building (0.4 ac) about an acre, producing approximately 3,441 ft^3 of runoff during a 1-inch storm event.

With this new design in mind, there are several opportunities to capture stormwater runoff from front lawns, streets, and other impervious surfaces with aesthetically pleasing and educational best management practices.

Design Considerations:

Several utilities exist throughout the Agricultural Mall site, most notably a large tunnel. These utilities present potential design conflicts. Any stormwater designs above these utilities may require a liner to prevent infiltration near the lines.

Several of the older academic buildings located along the Mall have external roof leaders that could be easily disconnected from the sewer system. This provides an opportunity to manage roof runoff for storage/re-use or by other volume reducing BMPs. Additionally, portions of both S. University Drive and Marsteller Street drain to the Mall and runoff from the streets may be diverted to BMPs located within the Mall area.

BMP Options:

- Porous Pavement Walkways, Bioswales/Tree Trenches, Rain Gardens and Sub-surface Infiltration Beds – The streets that will be converted to pedestrian areas should be designed to have a central strip of porous pavement. The current street width is more than adequate for pedestrian use, so the amount of paved area could potentially be reduced. Vegetated bioswale/tree trench systems could border these potentially porous pavement walkways. A subsurface infiltration bed could be designed to capture larger volumes where space is available.

- There is also potential to capture rainwater in cisterns for reuse off of buildings, the Entomology Lab, Forestry, and Horticulture Buildings.

Benefits:

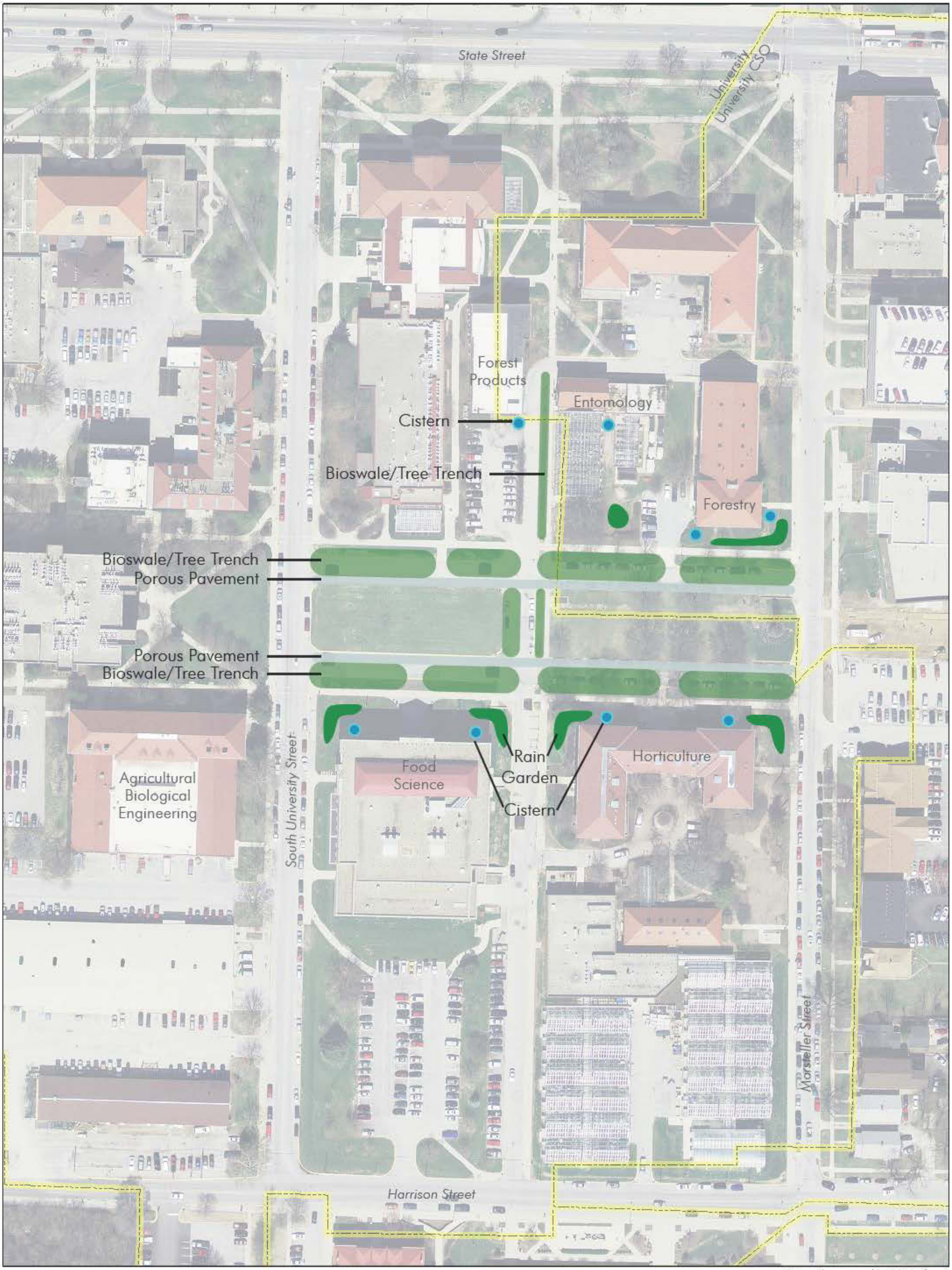
The capture and reuse of stormwater runoff from the streets, sidewalks, lawns and buildings in the Agricultural Mall drainage area will reduce the stormwater runoff loading on the University Storm Sewer System. The total estimated potential volume reduction achieved during a 1-inch storm event by the above recommendations is provided below:

Potential "capture" area:

AGRICULTURAL MALL	4.2 AC
ENTOMOLOGY LAB	0.3 AC
FORESTRY BUILDING	0.3 AC
HORTICULTURE BUILDING	0.4 AC
TOTAL AREA	5.2 AC

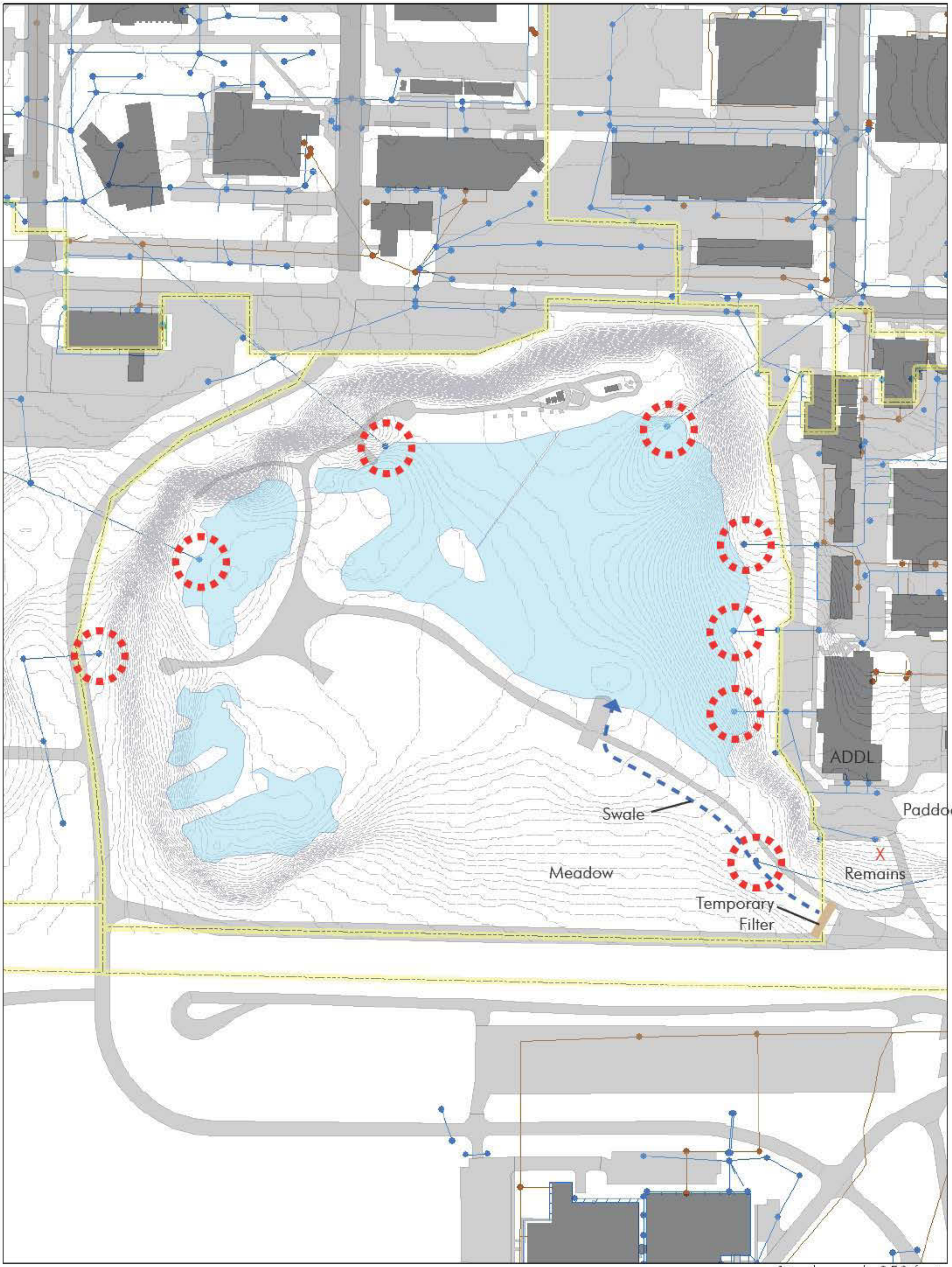
Drainage Area:

POROUS PAVEMENT, SUB-SURFACE BEDS, & BIORETENTION	3,470 CF
ENTOMOLOGY LAB CISTERNS	902 CF
FORESTRY BUILDING CISTERNS	901 CF
HORTICULTURE BUILDING CISTERNS	1,357 CF
TOTAL VOLUME	6,630 CF



1 inch equals 150 feet

Agricultural Mall Drive Reduction



1 inch equals 250 feet

Harrison Pond Pollution Prevention

Overview of issues:

Any stormwater intervention on the Purdue campus, with the exception of the Jordan Creek and the University CSO sewershed areas is going to contribute to Harrison Pond's pollution prevention. However, in addition to receiving stormwater piped from the upper campus via multiple discharge points, Harrison Pond also accepts surface drainage from adjacent facilities including the Animal Disease Diagnostics Lab and Wade Power Plant, as well as snow loading. Water quality is the main concern when dealing with surface runoff given the by-products produced from the surrounding buildings and the potential for contamination of not only the aquifer, but the flora and fauna within and adjacent to Harrison Pond.

Outlet - Discharge Point

Sub-shed Boundary

Existing Sanitary Sewer

Existing Storm Sewer

1' Contour

Drainage Area: Pond
* accepts conveyed drainage from 4 other drainage areas. See figure 3.4

Existing Conditions:

Wade Power Plant - An east/west service road currently drains to Harrison pond, taking with it deposited fly ash produced from the Wade coal burning plant to the east. A new fluidized bed boiler is replacing the oldest boiler at Wade and will be a proactive step toward reducing the plant's fine particulate matter emissions. However, contaminated runoff was observed and temporary filters have been set up to the south of the Harrison Pond entrance road to remove suspended solids. The large lobe of land where water drains, extends down into Harrison pond and was the former location of coal storage for the plant. Presently it is capped and has a meadow on top. Once past the temporary filter, water is directed to a vegetated swale in the meadow which runs along the south side of the Harrison Pond gravel road. Water that bypasses the filter, sheet-flows over the gravel road where depositions of fly ash and erosion problems were observed. Half way down Harrison Pond Road a concrete slab marks the point where water from the vegetated swale meets the road runoff and is diverted to Harrison Pond.

Wade Power Plant

Temporary Filtration Structure for Surface Runoff along Service Road

Animal Disease Diagnostics Lab – ADDL's parking lot/loading dock is drained directly into Harrison Pond via a series of stormwater sewers that combine and discharge at the pond's SE corner. Some water from this lot bypasses the inlets and flows down a gravel drive located at the lot's SE corner, slight erosion was observed. The animal paddocks to the east of the facility have piped drainage to the former coal storage lobe where it is then discharged and allowed to flow overland. Only serviced by one inlet, additional runoff from this area, runs down the hillside to the south, through stored slag piles at the base and eventually mixes with the runoff coming from the Wade Power Plant.

Meadow Over Top of Former Coal Storage with Stormwater Swale in the Foreground

Future Conditions:

Plans for the realignment of US 231 to the west of Harrison Pond will create a new entrance to the Purdue campus and provide direct views to the pond. Harrison Pond is an under-utilized asset and has the potential to be an impressive entrance to the campus and an opportunity to showcase Purdue's commitment to environmental sustainability. Additionally, it should be considered a future amenity to the ongoing development immediately surrounding it, as well as a destination for the rest of the campus. Water quality considerations should be kept in mind when the road is designed. This is also true for any new development that happens within the pond drainage area.

Gravel Road with Erosion Problems

The parcel between Wade and Harrison Pond is being considered for a Bio-Security Level 3 project. Increasing the amount of impervious along the service road will exacerbate runoff problems and the left over open space within the project parcel most likely will not be able to handle the volume of flow coming off the service road in addition to its own.

Accumulation of Particulate Matter on Concrete Slab where water is diverted to Harrison Pond.

Erosion along Gravel Drive @ ADDL

Coal burning is expected to be Purdue's main source of energy production for the near future. It should be noted that Wade meets all regulatory standards for its permits. However, with proposed development targeting that area and its new importance as an entrance to the campus, the fine particulates emanating from Wade's operations will most likely become a larger concern and should be dealt with pro-actively.

BMP Options:

1. Spill Control for ADDL Loading Dock – BMPs to reduce the volume and rate of runoff discharged from the parking area associated with ADDL will help prevent further erosion problems as well as reduce direct runoff to Harrison Pond. Infiltration trenches with earthen berms may be an option and could be located along the vegetated slope behind the parking area. A trench drain located at the entrance to the gravel drive and connected to the new interventions will prevent further erosion to the service drive draining to Harrison Pond. It should also be confirmed that the pollution prevention plan implemented at the laboratory is sufficient to prevent illicit discharges to the pond.

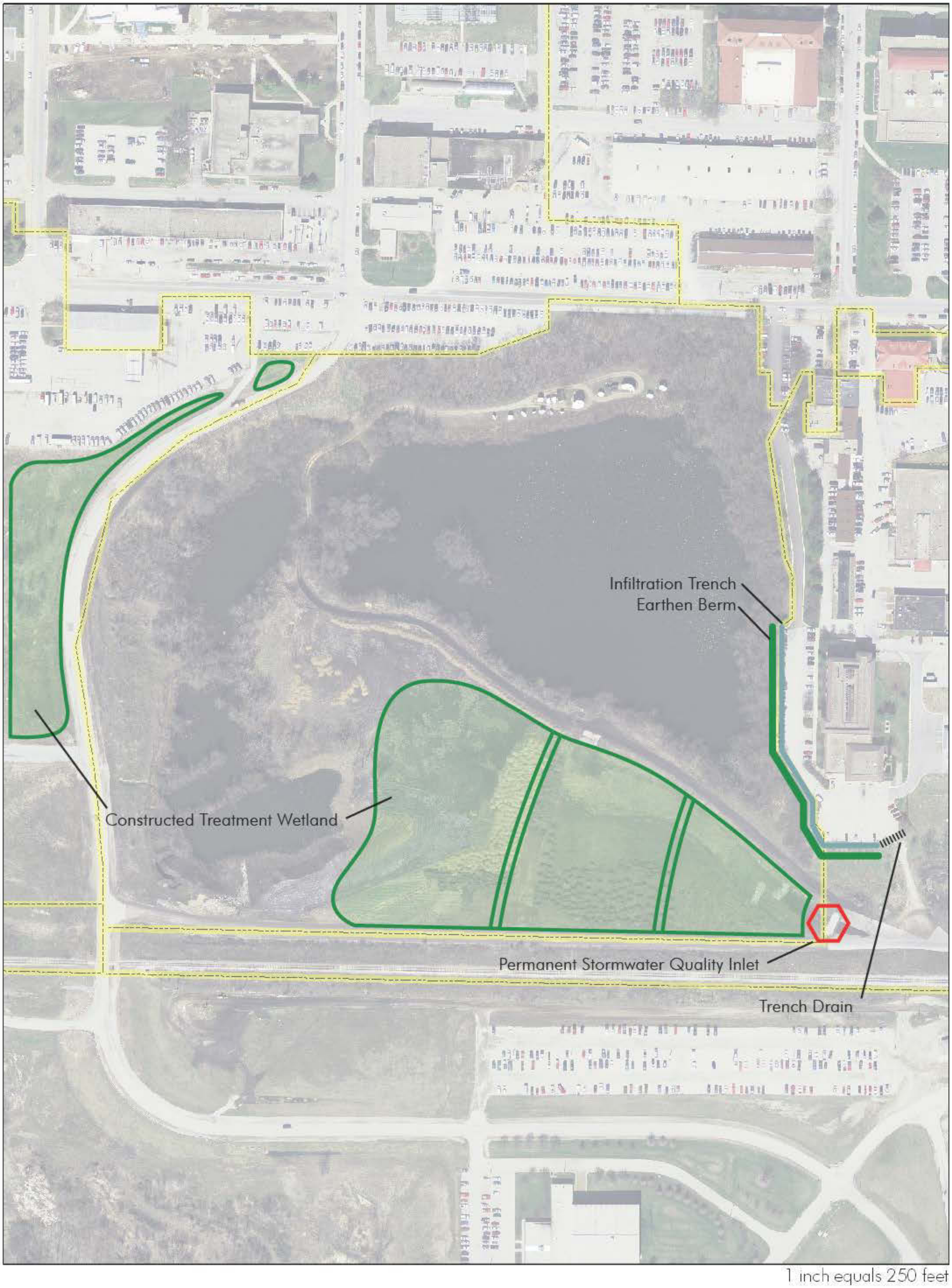
2. Paddock Area – Runoff having contact with animal waste (and fecal coliforms) from the paddock area should be managed on-site, rather than be discharged via overland flow or through existing storm sewers. This source of polluted stormwater could be managed with vegetated BMPs to first filter and then infiltrate runoff having contact with animal waste, sediment, and other non-point source pollutants associated with large animal holding areas.

3. Permanent Stormwater Quality Inlet/Forebay at Pond Service Road – Water quality vortex units or a structural forebay may be employed to provide sediment removal to clean and filter runoff prior to discharge to the vegetated swale adjacent to the pond. This measure would replace the existing hay bale filters located in this area and provide a more permanent solution.

4. Constructed Treatment Wetlands – A lined, constructed wetland situated on the former coal storage lobe adjacent to the pond could be installed to treat contaminated runoff via phytoremediation prior to discharge to Harrison Pond. The wetland should be reasonably sized to manage runoff generated by the areas surrounding Wade Power Plant. Additional wetlands could provide mitigation for the runoff coming from the parking areas surrounding Harrison Pond to the north and west.

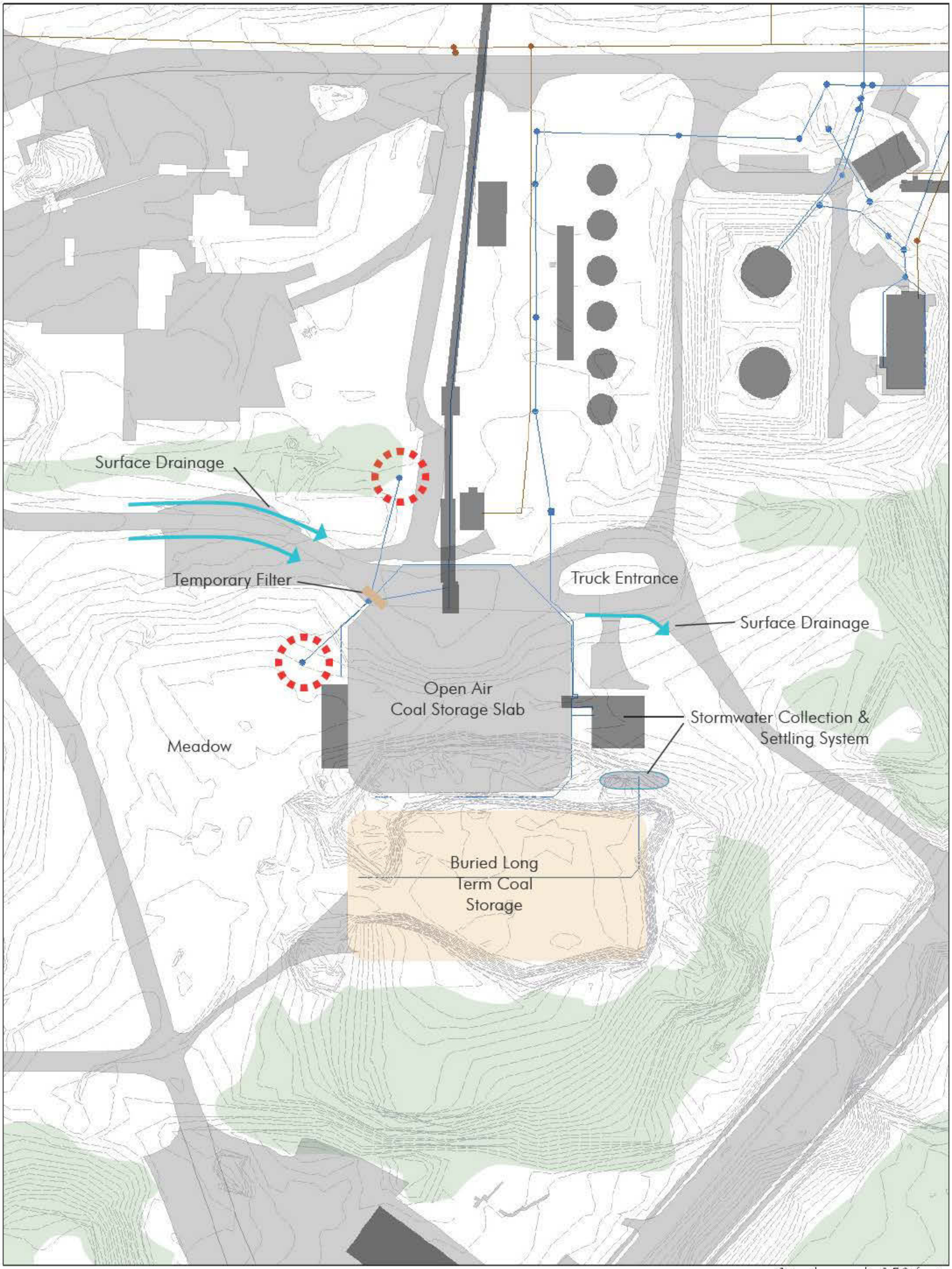
Benefits:

Water quality interventions adjacent to Harrison Pond will help in reducing direct pollutant loading to the Pond. Given the nature of the surrounding land uses, water quality measures in this area are a high priority to protect the pond and connected groundwater aquifer from degradation. Additionally, pollution prevention and water quality improvement in the pond will enhance aesthetics so that the pond and the area immediately adjacent to the pond can be utilized for passive recreation, education, and as a campus gateway.



1 inch equals 250 feet

Potential Location for Permanent Stormwater Quality Inlet



1 inch equals 150 feet

Coal Storage Area

Overview of issues:

Both piped and surface runoff are discharged into a wet meadow to the West of the open-air coal storage slab. A temporary filter for the inlet NW of the coal storage area needs to be replaced with a permanent one. Additional runoff at delivery the truck entrance should be captured and treated. Additional measures to ameliorate the hazards of open air coal storage should be explored. (ex. Fugitive coal dust emissions) Though no design standards for open air storage are required by the federal government as of Fall 2008, the National Association of Clean Air Agencies (NACAA), has been promoting the inclusion of open storage in the EPA's proposed rule revising the New Source Performance Standards (NSPS) for coal preparation plants under section 111(b)(1)(B) of the Clean Air Act (73 Federal Register 22901; April 28, 2008.

Scrub Area

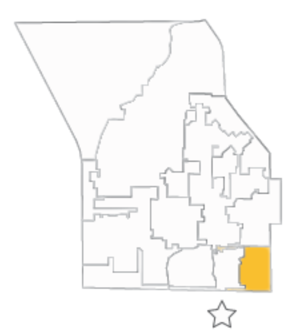
Outlet - Discharge Point

Sub-shed Boundary

Existing Sanitary Sewer

Existing Storm Sewer

1' Contour



Drainage Area: Offsite, outside of study boundary

Coal Delivery on Slab

Existing Conditions:

A concrete slab and surrounding curb is used to store coal for the Wade Power Plant. Additional long-term buried storage is located directly south of the slab. A leachate collection/treatment system with settling pools to the east of the slab was observed. However, additional drainage to the west flows to an inlet with a temporary filtration device (hay bales) and then is piped 120 feet and discharged to a meadow. A small portion by the delivery entrance (no curb) drains to the east down a gravel road toward a meadow. Evidence of deposition on the grass side of the curb was observed in some areas.

Consideration:

Due to the nature of the contaminants generated by the Coal Storage Area (i.e., acid leachates, heavy metals), further study is necessary to understand the potential impacts of uncovered coal storage and to provide a sustainable treatment solution for this area. Because of the known subsurface connection between Harrison Pond and the groundwater aquifer, management of runoff from the coal storage area is a high priority and should be addressed within a separate study to prevent potential further degradation of the aquifer and Harrison Pond (see Cook and Fritz, 2001).

Deposition of Coal Particulates in the Foreground, Inlet with Temporary Filtration Device in the Mid-ground, and Meadow in the Background.

BMP Options :

Permanent Stormwater Quality Treatment Unit – A permanent water quality treatment unit should be installed to replace the temporary filter located on the west side of the coal storage area. This treatment unit would serve as an initial filtering measure for a portion of the coal storage area.

Enhanced Treatment System – The existing pollution prevention plan for the coal storage area should be reassessed in order to reduce, to the maximum extent practicable, existing surface runoff from areas associated with coal storage and its delivery. Phytoremediation may provide adequate treatment of the pollutant laden runoff generated by the storage area and surrounds, lining of these systems should be considered to prevent infiltration before treatment. Airborne fugitive coal dust should also be considered, but is out of the realm of this report.

Temporary Filtration Device at Inlet

Benefits:

Efforts to reduce or eliminate the discharge of runoff that contains acid leachates and heavy metals will provide protection of Purdue's essential groundwater resources.

1 inch equals 150 feet

Inlet with Temporary Filtration Device in the Mid-ground, and Meadow in the Background.