Supplemental Reapplication Materials

Ada County Highway District MS4 Summary

Supplemental Reapplication Materials – ACHD MS4 Summary Description and Map

The MS4 Phase I permit area is composed of the City of Boise and Garden City, Idaho. The storm drain system in the Boise area is characterized by areas north and northeast of the Boise River that drain directly to the Boise River, while areas south of the Boise River drain to Boise River tributaries and/or irrigation related facilities, many of which eventually drain to the Boise River. Stormwater facilities on private properties built after 1980 drain primarily on-site via infiltration facilities. In Garden City much of the stormwater drains to the Boise River and irrigation-related facilities that drain to the Boise River. ACHD owns and operates all public roadways and associated stormwater conveyances in the Phase I permit area except roadways and stormwater facilities operated by ITD District 3.

ACHD's current inventory of stormwater facilities in the Phase I Permit area are detailed in Table 1.

Table 1. Phase I Area Stormwater Facility Inventory

Structure Type	Inventory (November 2017)
Storm Drain Pipe (miles)	337
ACHD Outfalls	686
Total Outfalls (ACHD, permittee, and private)	1,001
Catch Basins	12,288
Sediment/combo boxes	2,308
Proprietary Hydrodynamic BMPs	10
Seepage Beds	1,144
Swales	69
Stormwater Tree Trench	18
Pervious Paver Installations	5
Dry Wells	19
ACHD Basins (detention and retention)	47
Homeowner Association Basins (detention and retention)	129

In the Permit area there are 1,001 outfalls inventoried to date; 686 are owned and operated by ACHD while the others are owned by other permittees, Ada County, or are private. ACHD owns and operates 47 stormwater basins in the Phase I Permit area. The remaining basins are privately-owned or owned by other public entities. ACHD is responsible for heavy maintenance activities, e.g. dredging, on the private ponds while the homeowner's association or other private party(s) is responsible for the regular, light maintenance activities, e.g. landscape maintenance.

The ACHD Phase I MS4 Inventory Maps follow. Each map is divided into six sections to show a more detailed view of storm water drainage system features. In the bottom left corner of the map, a spatial grid index shows columns A, B, and C along with rows 1, 2, and 3. The features of the comprehensive map can be turned on and off in the *Layers* tab of the PDF document. This allows viewers to determine which features are visible.

Supplemental Reapplication Materials

Ada County Highway District Inventory Map

Phase I MS4 Inventory Map

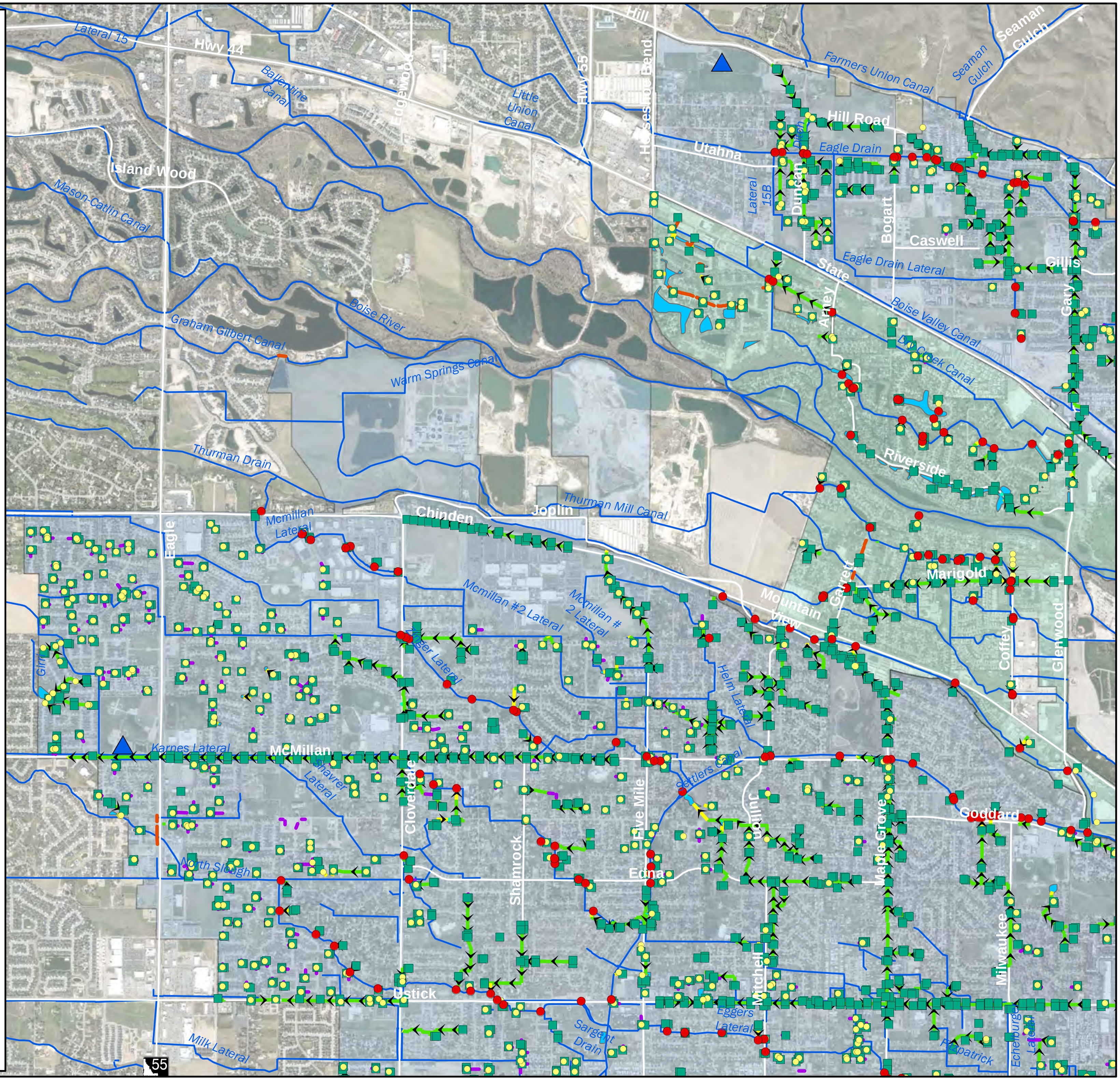
2017

- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD
Committed to Service

Phase I Area: Map A1



0 0.2 0.4 0.8 Miles

Phase I MS4 Inventory Map

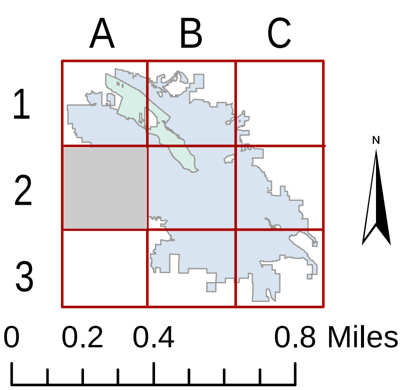
2017

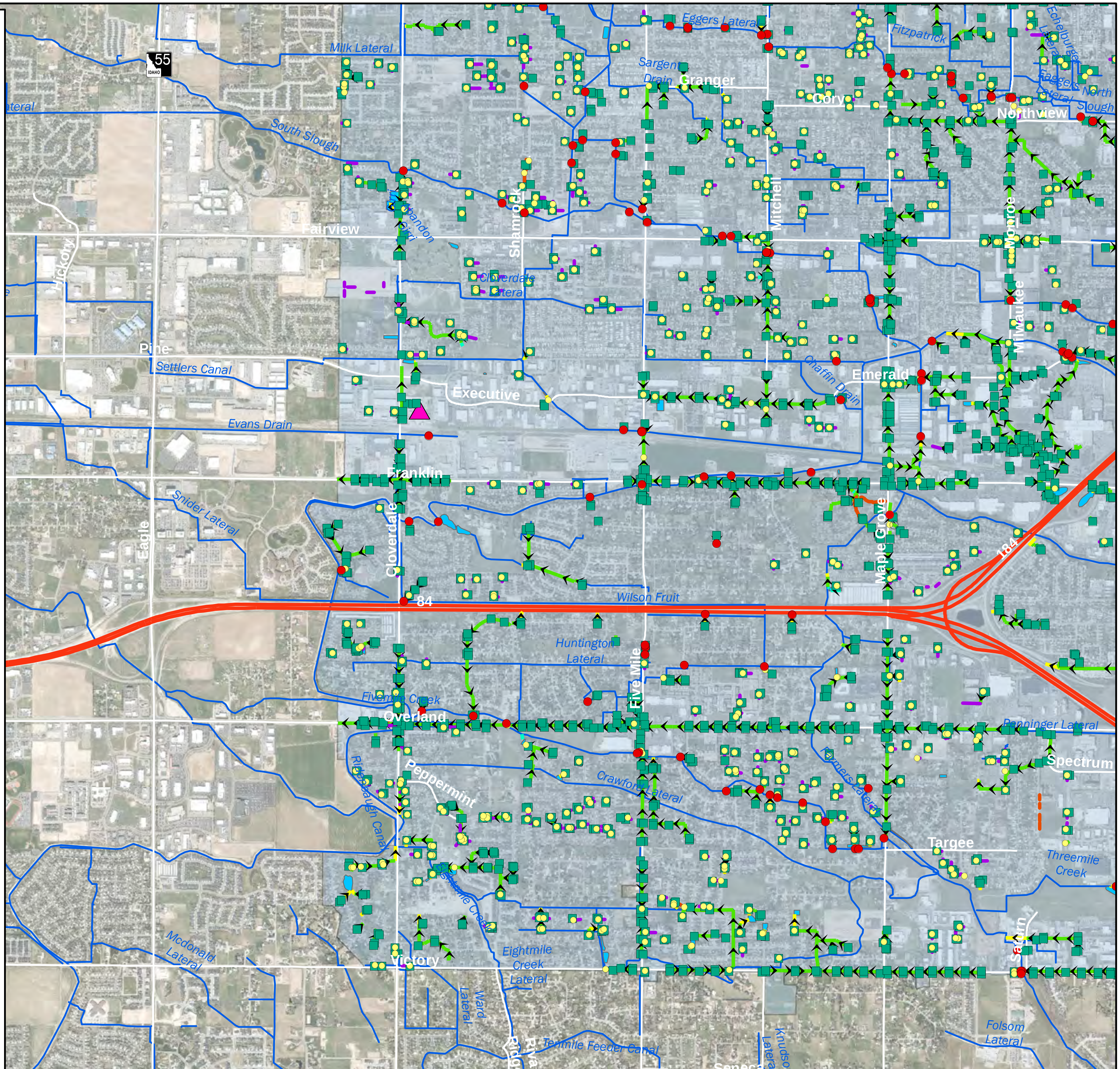
- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD
Committed to Service

Phase I Area: Map A2





Phase I MS4 Inventory Map

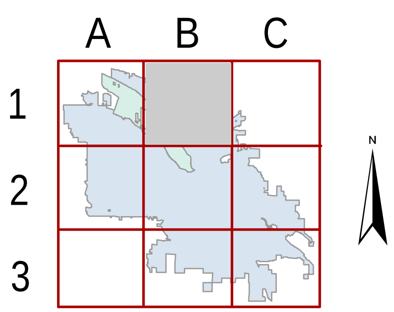
2017

- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD Committed to Service

Phase I Area: Map B1



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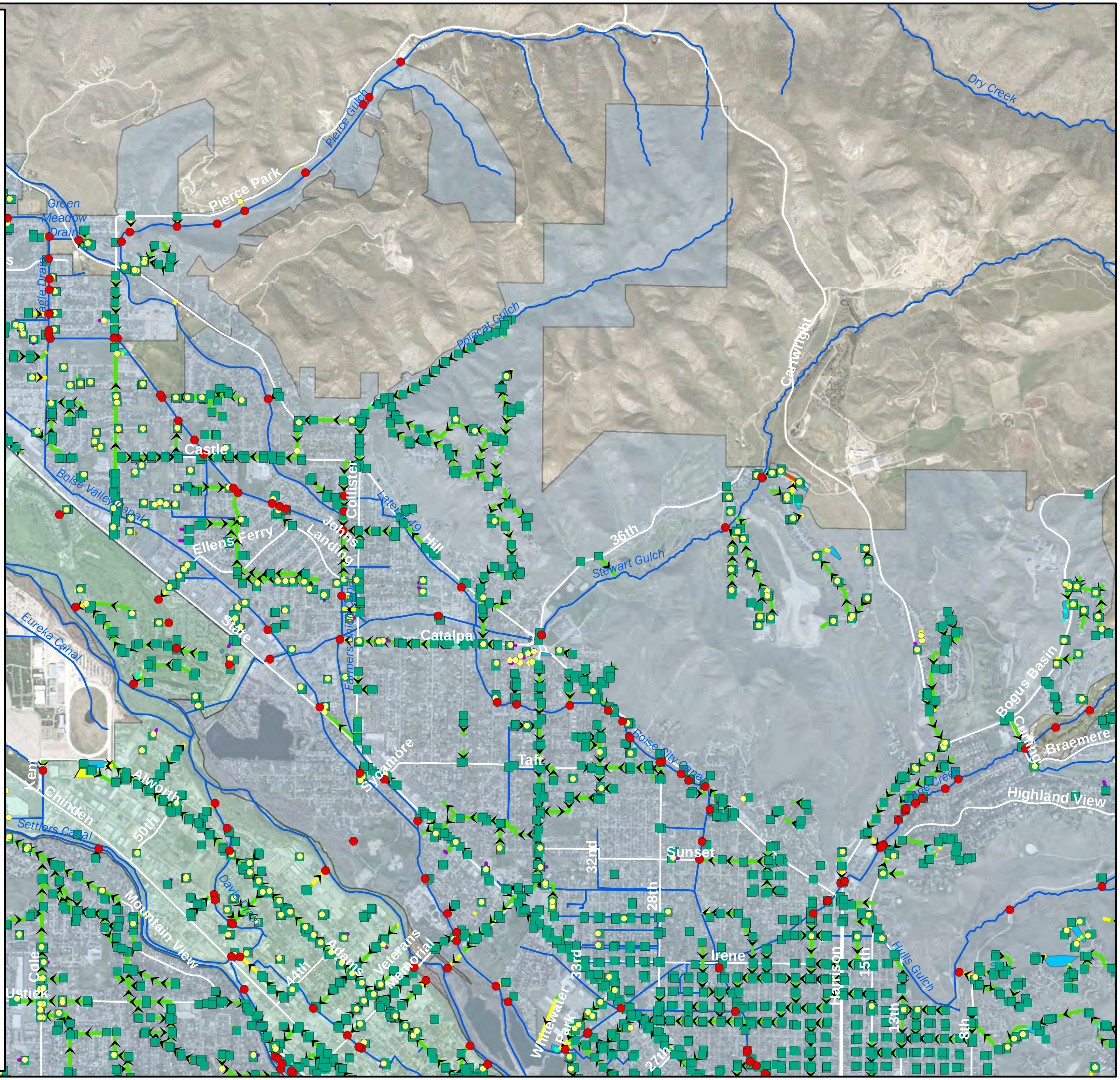


Phase I MS4 Inventory Map

2017

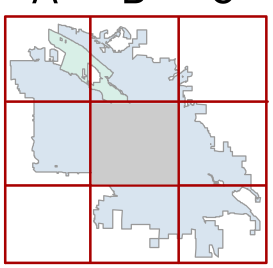
- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD

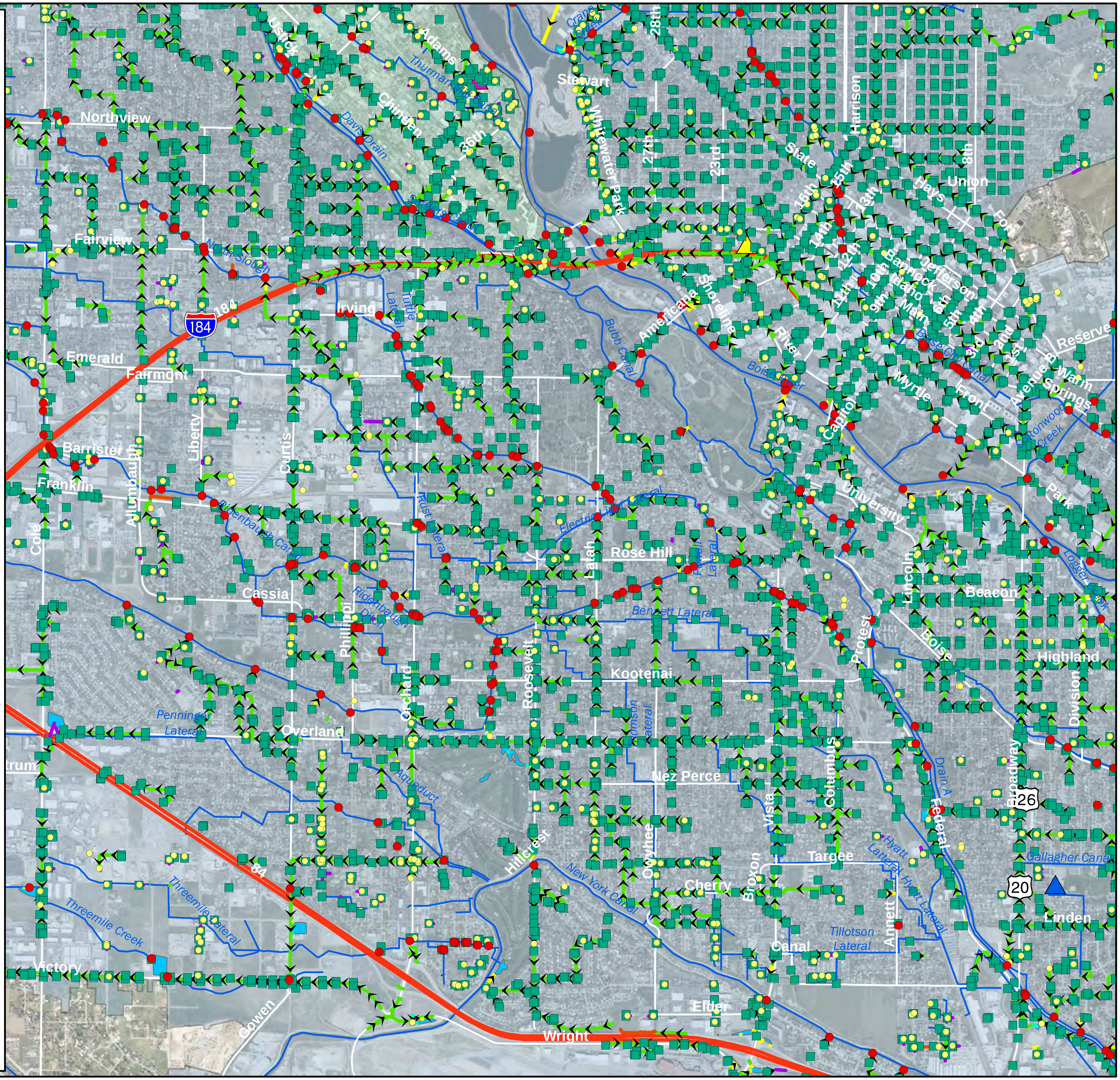
Committed to Service

Phase I Area: Map B2



0 0.2 0.4 0.8 Miles

N



Phase I MS4 Inventory Map

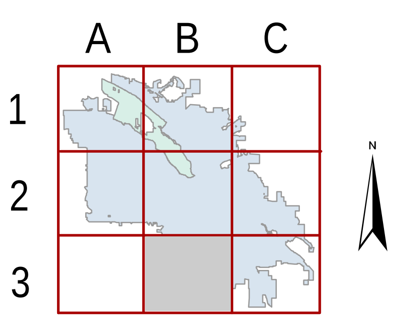
2017

- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD
Committed to Service

Phase I Area: Map B3



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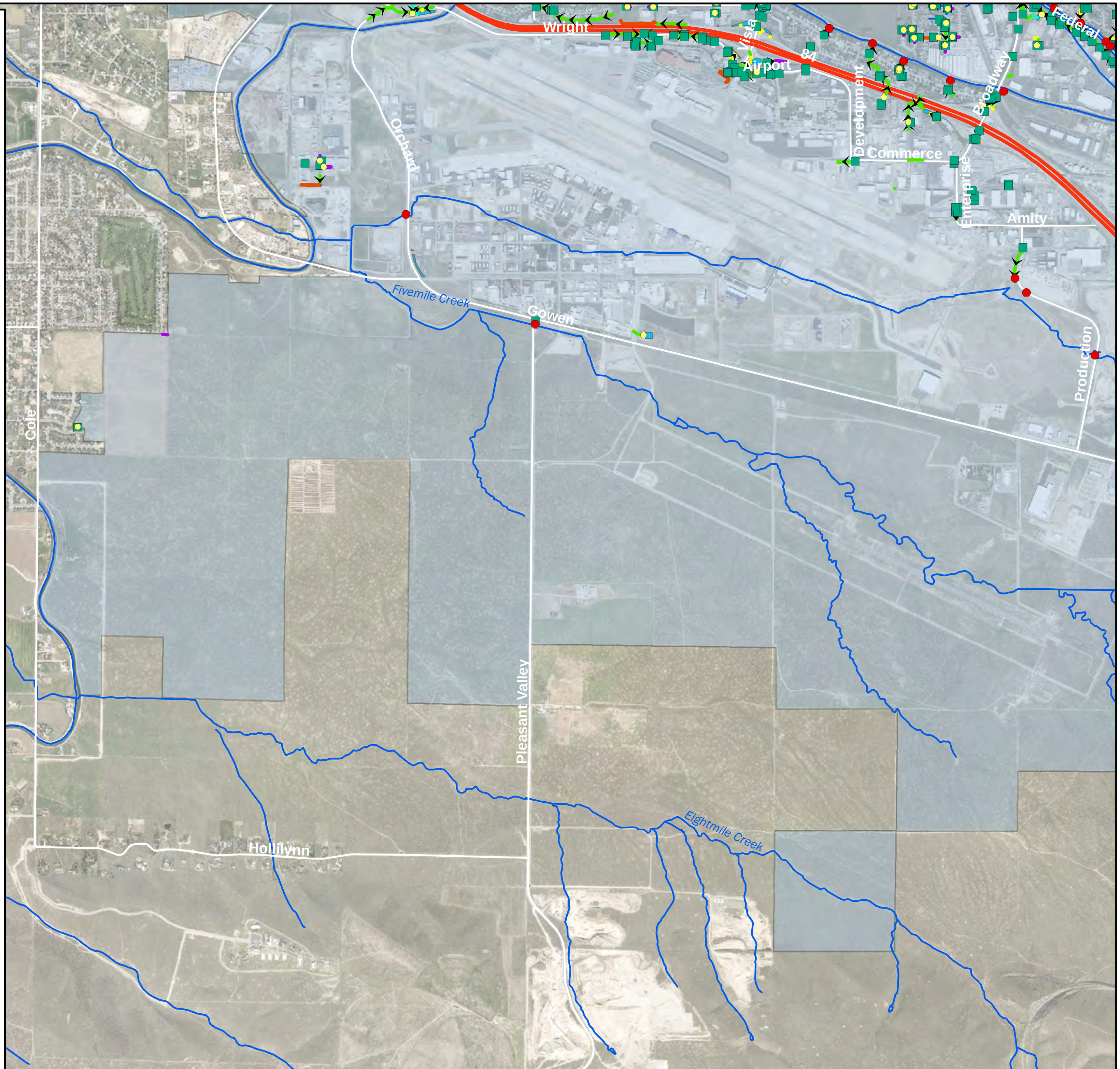


Phase I MS4 Inventory Map

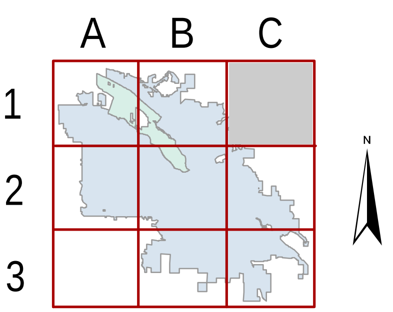
2017

- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD Committed to Service

Phase I Area: Map C1



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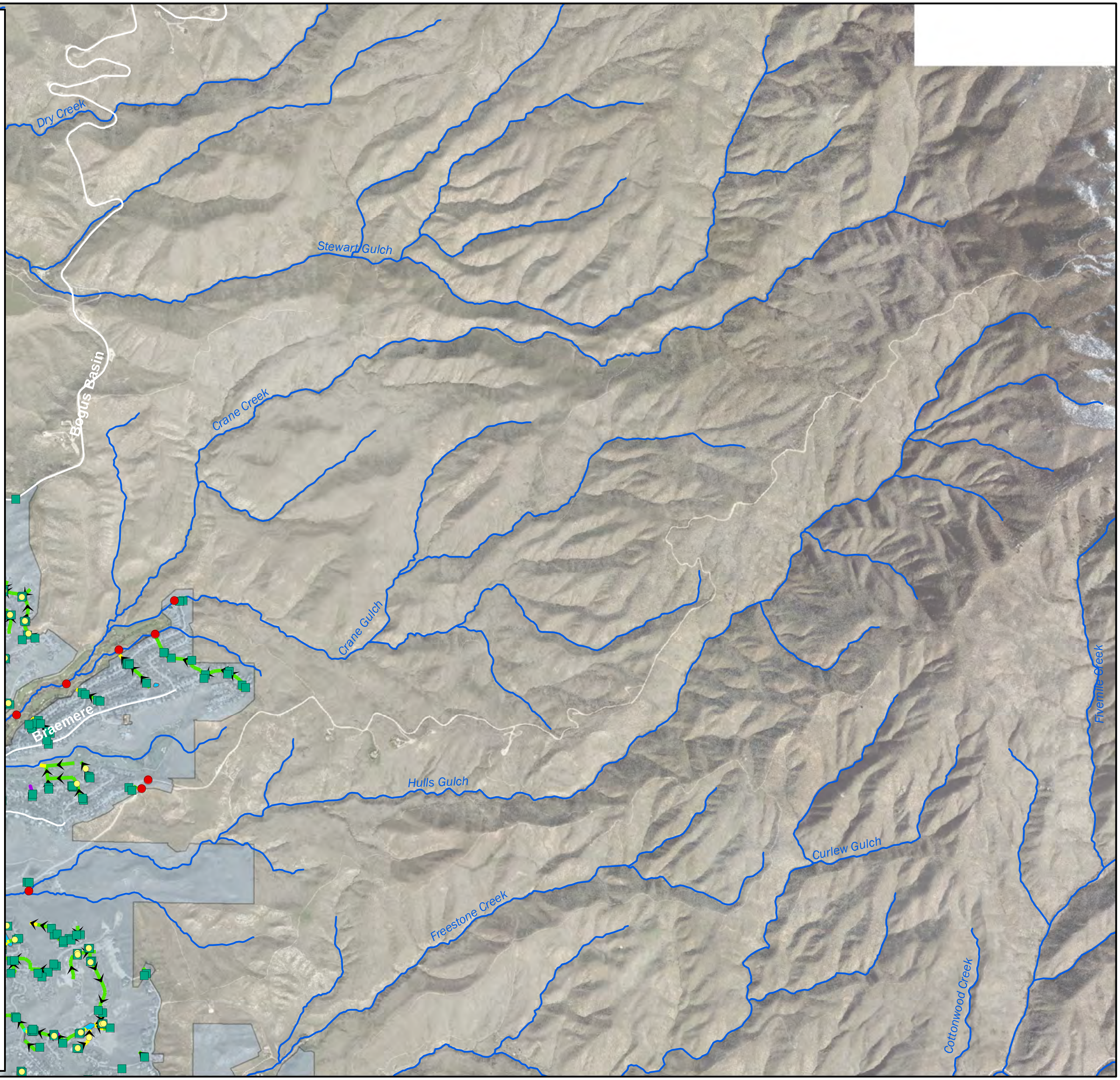
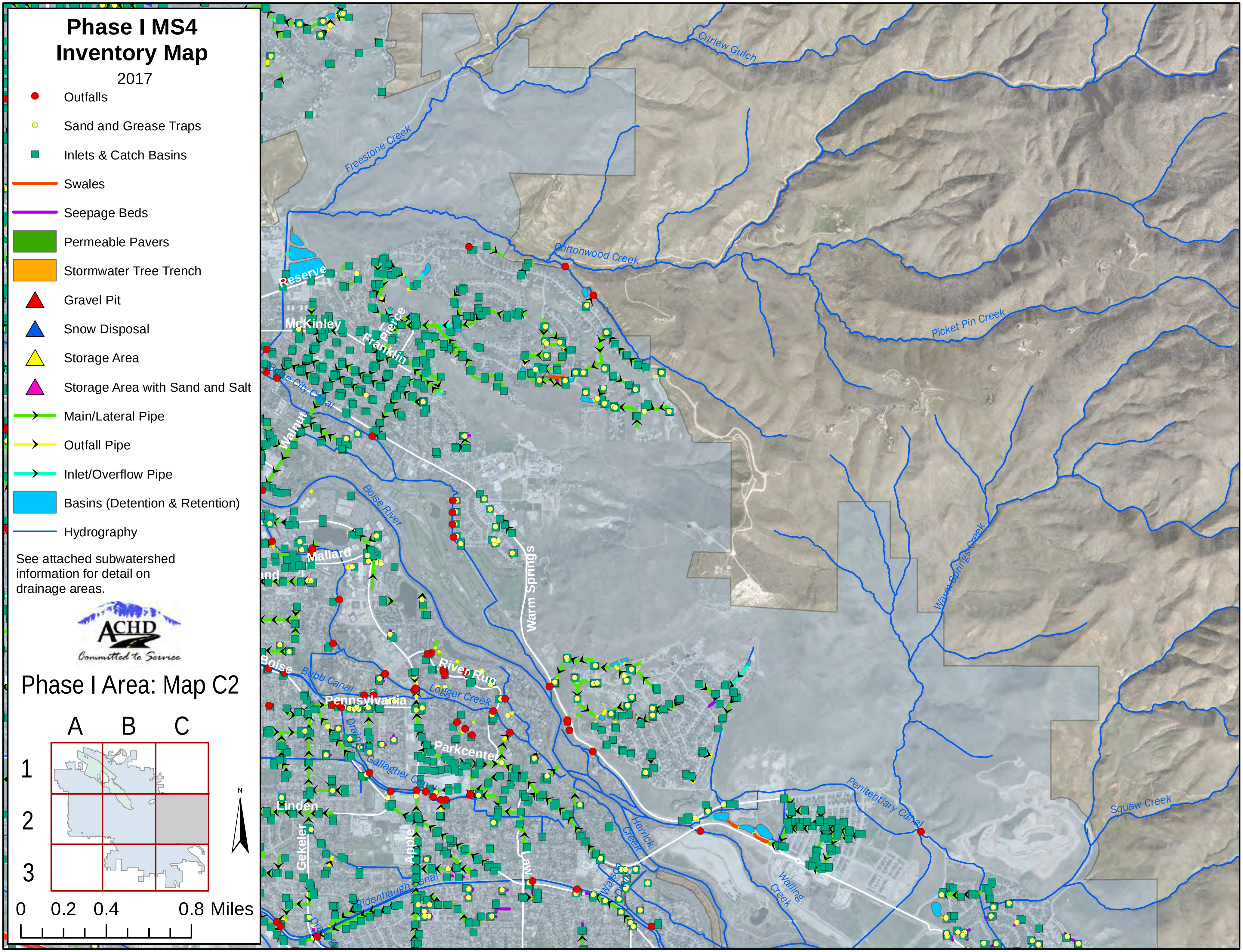



Phase I MS4 Inventory Map
2017
Outfalls
Sand and Grease Traps
Inlets & Catch Basins
Swales
Seepage Beds
Permeable Pavers
Stormwater Tree Trench
Gravel Pit
Snow Disposal
Storage Area
Storage Area with Sand and Salt
Main/Lateral Pipe
Outfall Pipe
Inlet/Overflow Pipe
Basins (Detention & Retention)
Hydrography
See attached subwatershed information for detail on drainage areas.
ACHD
Committed to Service
Phase I Area: Map C2
A
B
C
1
2
3
N
0
0.2
0.4
0.8 Miles
Curlew Gulch
Freestone Creek
Cottonwood Creek
Picket Pin Creek
Warm Springs Creek
Squaw Creek
Penitentiary Canal
Reserve
McKinley
Pierce
Franklin
Boise City Canal
Walnut
Boise River
Mallard
Warm Springs
River Run
Logger Creek
Bubb Canal
Boise
Pennsylvania
Parkcenter
Gallagher Canal
Linden
Gekeler
Apple
Law
Ridenbaugh Canal
Herrick Creek
Walling Creek

Phase I MS4 Inventory Map

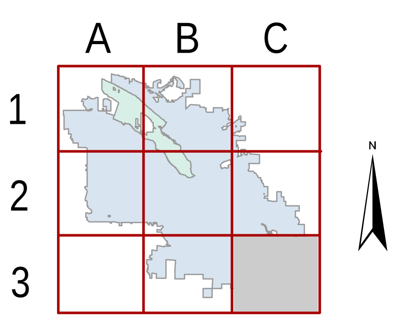
2017

- Outfalls
- Sand and Grease Traps
- Inlets & Catch Basins
- Swales
- Seepage Beds
- Permeable Pavers
- Stormwater Tree Trench
- Gravel Pit
- Snow Disposal
- Storage Area
- Storage Area with Sand and Salt
- Main/Lateral Pipe
- Outfall Pipe
- Inlet/Overflow Pipe
- Basins (Detention & Retention)
- Hydrography

See attached subwatershed information for detail on drainage areas.

ACHD
Committed to Service

Phase I Area: Map C3



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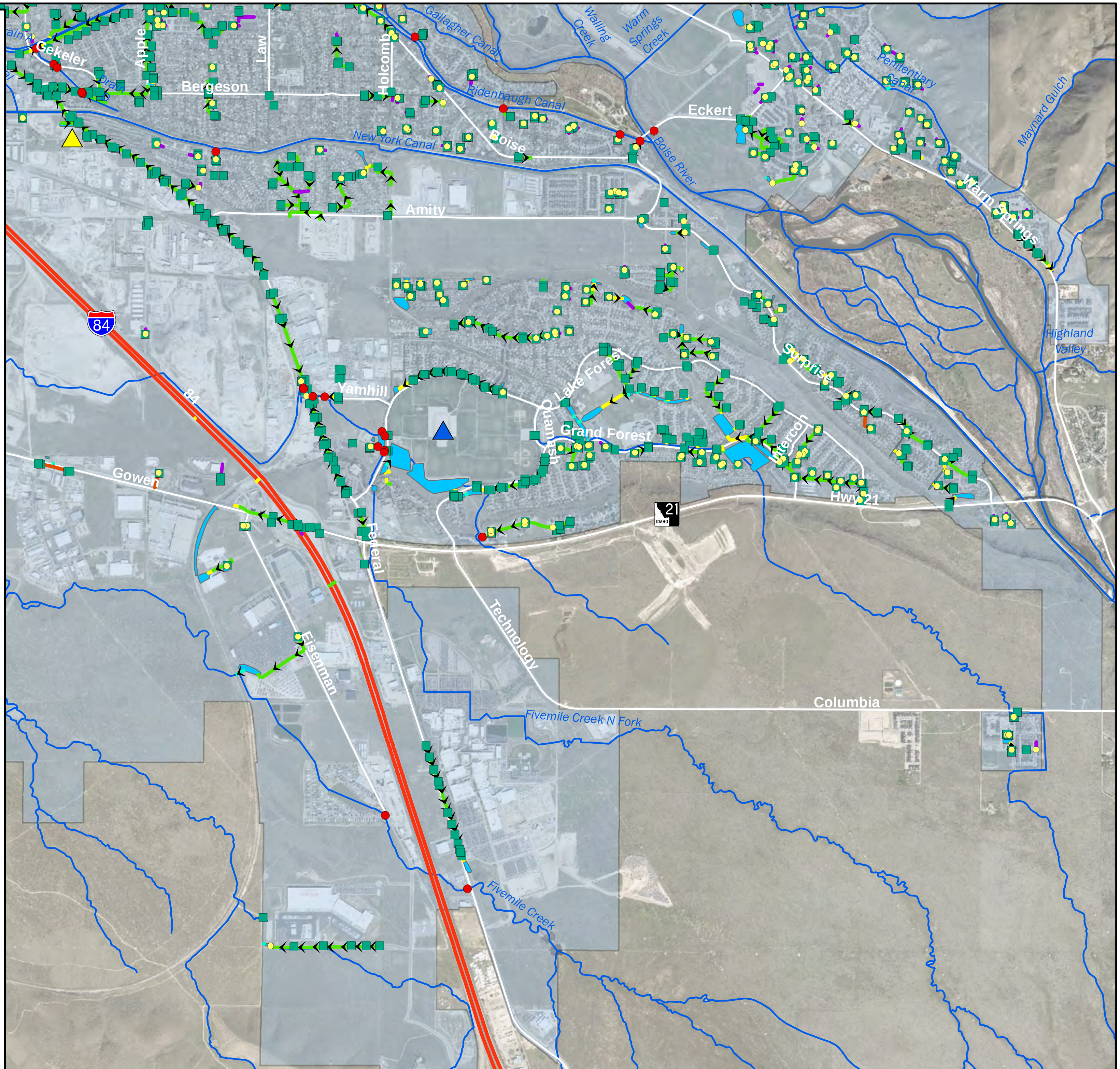


Supplemental Reapplication Materials

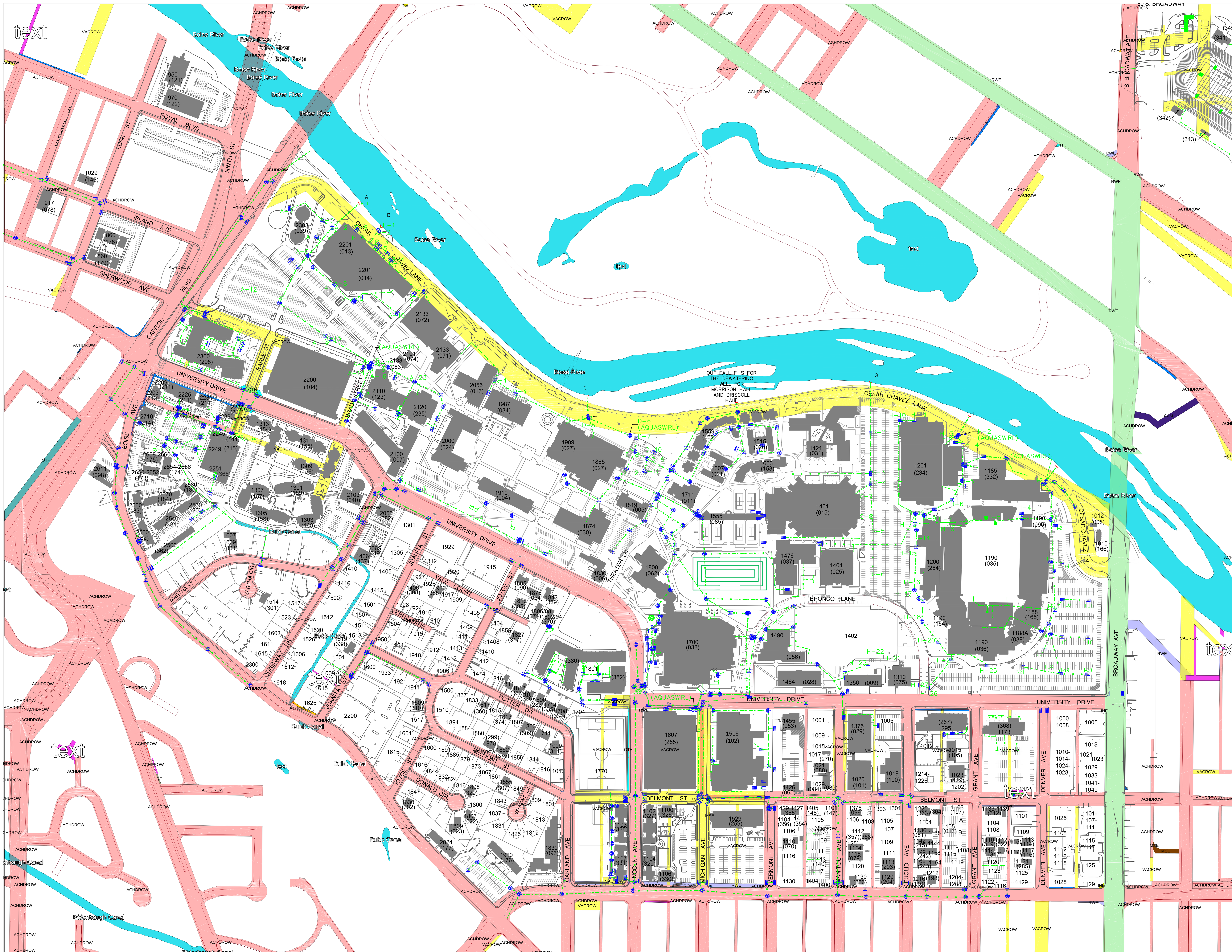
Boise State University MS4 Summary

Boise State University is located next to the south bank of the Boise River, near the center of downtown Boise. Boise State University's 215-acre main campus is bordered to the north by the Boise River, to the south by Beacon Avenue, to the east by Broadway Avenue, and to the west by Ann Morrison Park with the majority of parcels between Beacon, University and Boise Avenues. Boise State University's main campus and off-site areas are composed of buildings, maintained lawns, landscaped areas, concrete sidewalks, asphalt-paved driveways and parking areas, parking garages, certain streets owned by Boise State University, a sports stadium with roof areas and multiple artificial turf fields. The main campus and off-site locations, which drain to the lower Boise River or a tributary, are comprised of ten sub-basin drainage areas which drain impervious surface to twelve separate outfalls.

Feature	Quantity	Notes
Total acreage	233.5 acres	Includes main campus and 2 off-site locations
Outfalls	12	
Vortex devices	5	Remove sediment and debris
Sand and grease separators	27	
Onsite infiltration systems	8	
Catch basins	212	
Inspection frequency for all structures occurs on an annual basis and results of the inspections are included in the Annual Report. Structures are cleaned on an as-needed basis.		

Supplemental Reapplication Materials

Boise State University Inventory Map



LEGEND

Easement

- Storm Water
- SIE (Sidewalk)
- RWE (Road)
- INE (Intersection)
- CAM (Cross Access)
- RC (River/Canal)
- MSE (Miscellaneous)
- DIE (Drainage Irrigation)

Right of Way

- ACHD
- ITD
- River Canal
- VAC
- OPUB (Public Agency)

- Ada County Water Features
- Bridges
- Edge of Pavement
- Ada County Parcels

SYMBOLS

- DRAIN/CATCH BASIN
- STORM DRAIN OUTLET
- PULLBOX/VAULT
- MANHOLE

BOISE STATE UNIVERSITY
ARCHITECTURE AND ENGINEERING SERVICES

DRAWING TITLE: Campus Right Of Way Storm Drain

REVISION DATE: 12.2017

Scale 1"=200'

NOTE: MAPS ARE FOR REFERENCE ONLY. CALL (DIGLINE) BEFORE EXCAVATING.

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Supplemental Reapplication Materials

City of Boise MS4 Summary

CITY OF BOISE
MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) PERMIT

SUPPLEMENTAL REAPPLICATION MATERIALS
DECEMBER 15, 2017

The following materials are submitted as a supplement to the re-application package which was submitted to the United States Environmental Protection Agency (EPA) on July 28, 2017. These materials are intended to address the requirements of Permit Section II.B.4.a.(i)-(vii).

Summary Description of the City's Storm Sewer System

The City of Boise is directly responsible for discharges from storm sewer systems and outfalls which the City owns and/or operates. These areas are generally limited to City owned properties and flood control structures owned or operated by the City which are associated with the natural and modified foothills floodway conveyance systems, ponds, and dams.

Properties owned or operated by the City that have direct discharge to surface water bodies include: Julia Davis Park, Ann Morrison Park and the Fire Department Training Station. The parking areas of the Boise Library, Log Cabin, and Library Annex discharge into a large diameter ACHD MS4 pipe 250 feet from its river outfall. All of these outfalls existed before the effective date of the 2012 Boise/Garden City Area MS4 permit.

All other City properties either (1) retain and infiltrate an approximate 1-inch depth of stormwater per 24/hour precipitation event; (2) discharge stormwater under another NPDES permit (e.g., Lander Street and West Boise Water Renewal Facilities, Boise Airport); or (3) discharge stormwater to another jurisdiction by their permission (drainage or irrigation entity, ACHD, state highway, etc.).

It is noted that discharge from the majority of the Boise Airport property is authorized by a Multi-Sector General Permit for Stormwater Discharge from Industrial Activities.

Section II.B.4.a requires an inventory of the MS4 and associated outfall locations in areas where the permittee has responsibility. The inventory must include:

(i) The location of all inlets, catch basins and outfalls owned/operated by the Permittee;

The location of all City owned or operated inlets and catch basins is maintained in the City's proprietary asset management database "Vue Works". These locations are mapped electronically in a web-based GIS interface accessible to the City stormwater staff and City Department staff responsible for the maintenance of stormwater infrastructure. Due to the significant number and geographic scope of the facilities, a printed map is not provided with the supplemental materials.

Maps of the regulated outfalls owned or operated by the City, including the identification receiving waters, associated land uses, and approximate drainage areas in acres, are included with the supplemental materials and with the City's 2017 Annual Report.

(ii) The location of all MS4 collection system pipes (laterals, mains, etc.) owned/operated by the Permittee, including locations where the MS4 is physically interconnected to the MS4 of another operator;

The locations of all City owned or operated collection system pipes are maintained in the City's proprietary asset management database "Vue Works". These locations are mapped electronically in a web-based GIS interface accessible to the City stormwater staff and City Department staff responsible for the maintenance of stormwater infrastructure. Due to the significant number and geographic scope of the facilities, a printed map is not provided with the supplemental materials.

Maps of the interconnections of the City's MS4 to the MS4 of another operator are included with the supplemental materials and with the City's 2017 Annual Report.

(iii) The location of all structural flood control devices, if different from the characteristics listed above;

Maps of the locations of City owned or operated structural flood control devices are included with the supplemental materials and with the City's 2017 Annual Report.

(iv) The names and locations of receiving waters of the U.S. that receive discharges from the outfalls;

Please see II.B.4.a.(i) above.

(v) The location of all existing structural storm water treatment controls;

The locations of all City owned or operated structural storm water treatment controls are maintained in the City's proprietary asset management database "Vue Works". These locations are mapped electronically in a web-based GIS interface accessible to the City stormwater staff and City Department staff responsible for the maintenance of stormwater infrastructure. Due to the significant number and geographic scope of the facilities, a printed map is not provided with the supplemental materials.

(vi) Identification of subwatersheds, associated land uses, and approximate acreage draining into each MS4 outfall; and

Please see II.B.4.a.(i) above

(vii) The location of Permittee-owned vehicle maintenance facilities, material storage facilities, maintenance yards, and snow disposal sites; Permittee-owned or operated parking lots and roadways.

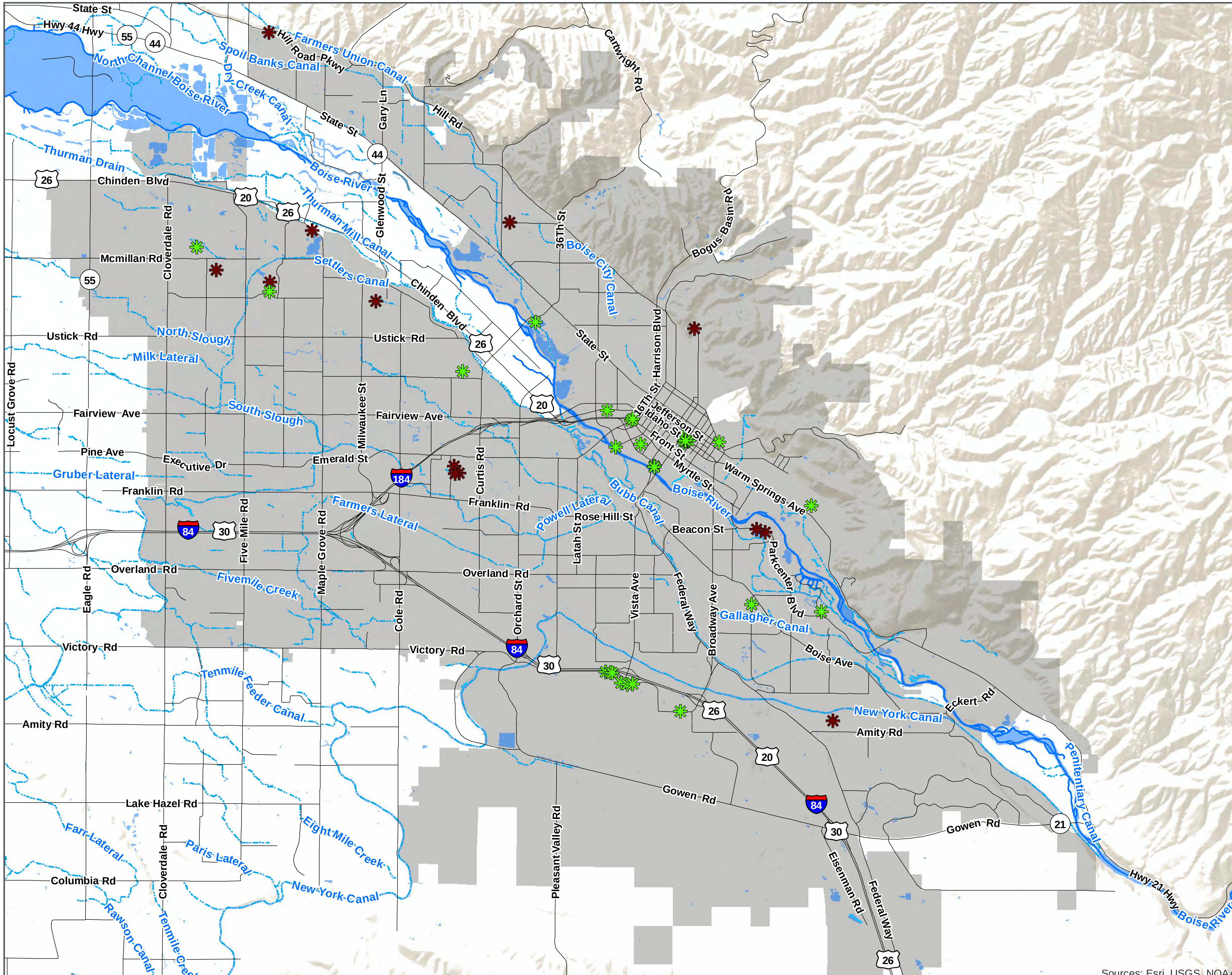
The locations of all City owned or operated vehicle maintenance facilities, material storage facilities, maintenance yards and snow disposal sites are maintained in the City's proprietary asset management database "Vue Works". These locations are mapped electronically in a web-based GIS interface accessible to the City stormwater staff and City Department staff responsible for the maintenance of stormwater infrastructure. Due to the significant number and geographic scope of the facilities, a printed map is not provided with the supplemental materials.

Attachments

Outfall Map(s)
MS4 Interconnections Map
Structural Flood Controls Map

Supplemental Reapplication Materials

City of Boise MS4 Interconnections



City of Boise MS4 Program Development

City of Boise Interconnection Locations

Legend

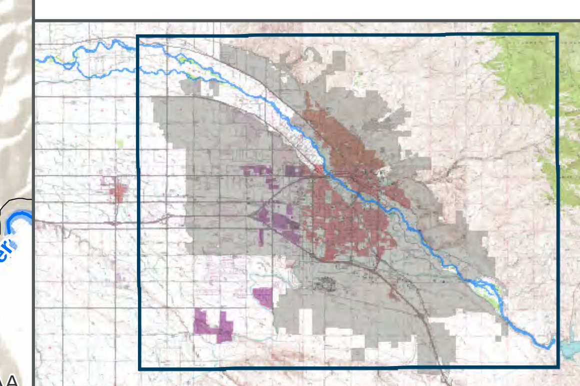
- Interconnection to Other Regulated MS4 from COB
- Interconnection from Other Regulated MS4 to COB
- City of Boise City Limits
- Surface Water

DATA SOURCES:
Boise City, Ada County, COMPASS, USDA

N

0 6,500 13,000
Feet

DISCLAIMER:
o This drawing is to be used only for reference purposes; Boise City is not responsible for any Inaccuracies herein contained.
o This map is made in part from data prepared or compiled by Ada County. Ada County shall not be liable for inaccuracies or misuse of this map or data.



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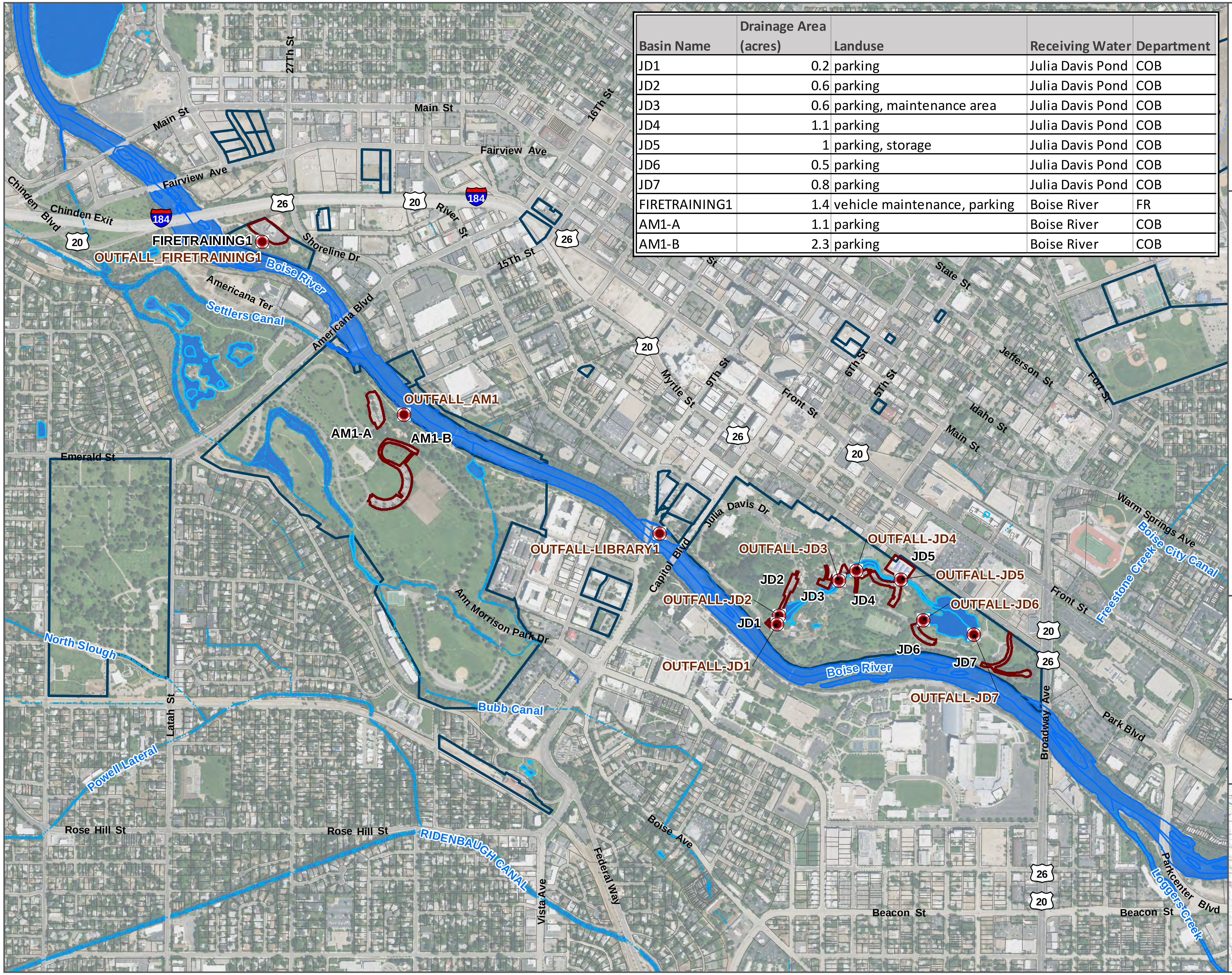
Supplemental Reapplication Materials

Boise City Outfalls 1

Basin Name	Drainage Area (acres)	Landuse	Receiving Water	Department
JD1	0.2	parking	Julia Davis Pond	COB
JD2	0.6	parking	Julia Davis Pond	COB
JD3	0.6	parking, maintenance area	Julia Davis Pond	COB
JD4	1.1	parking	Julia Davis Pond	COB
JD5	1	parking, storage	Julia Davis Pond	COB
JD6	0.5	parking	Julia Davis Pond	COB
JD7	0.8	parking	Julia Davis Pond	COB
FIRETRAINING1	1.4	vehicle maintenance, parking	Boise River	FR
AM1-A	1.1	parking	Boise River	COB
AM1-B	2.3	parking	Boise River	COB



City of Boise MS4 Program Development

City of Boise Outfall Locations

BOISE CITY OF TREES

Legend

- City of Boise Outfall Location
- Drainage
- Canal/Ditch
- Pond
- River/Stream
- Ephemeral Stream
- City of Boise Property
- Property Boundary

DATA SOURCES:
Boise City, Ada County, COMPASS, USDA

N

0 1,000 2,000
Feet

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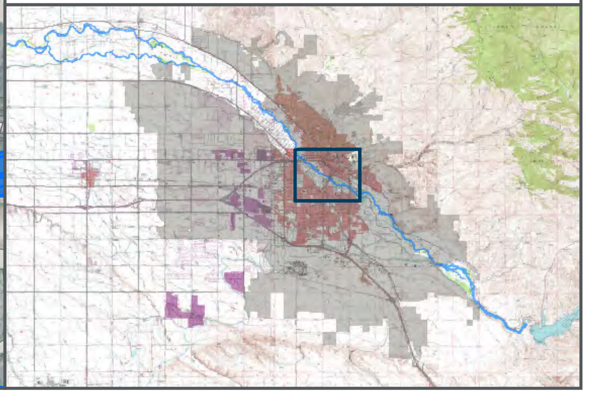

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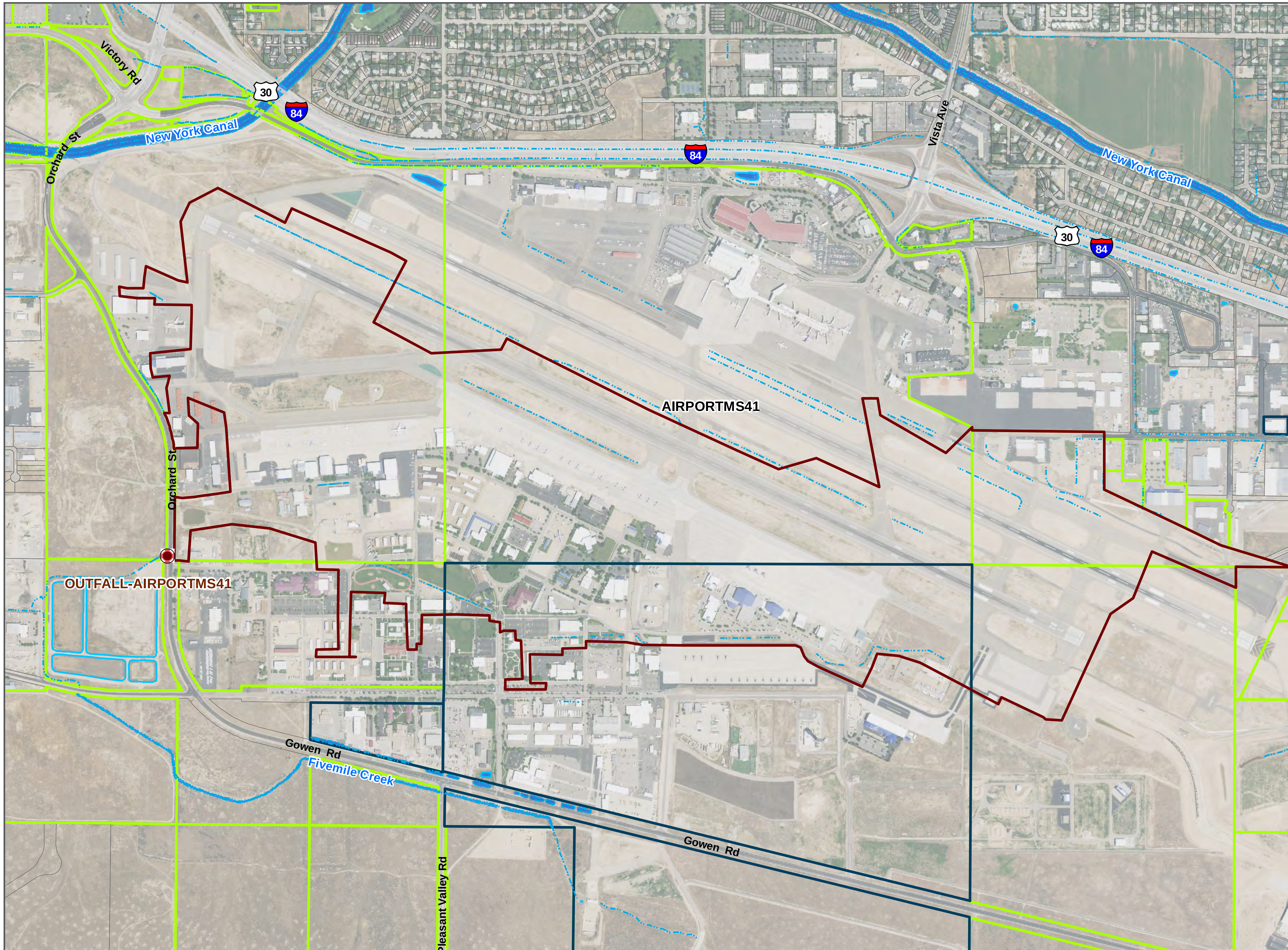
Supplemental Reapplication Materials

Boise City Outfalls 2



City of Boise MS4 Program Development

City of Boise Outfall Locations

Legend

- City of Boise Outfall Location
- Drainage Area
- Canal/Ditch
- Pond
- Ephemeral Stream
- Intermittent Stream
- City of Boise Property
- City of Boise Air Terminal Property
- Property Boundary

DATA SOURCES:
Boise City, Ada County, COMPASS, USDA

N

0 1,000 2,000
Feet

DISCLAIMER:
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Basin Name	Drainage Area (acres)	Landuse	Receiving Water	Department
AIRPORTMS41	584.5	runway, parking, maintenance	Fivemile Creek	COB_AT

Note: Due to design configuration, the Aeronca stormwater facility, just upstream of this outfall only discharges during extreme precipitation events.

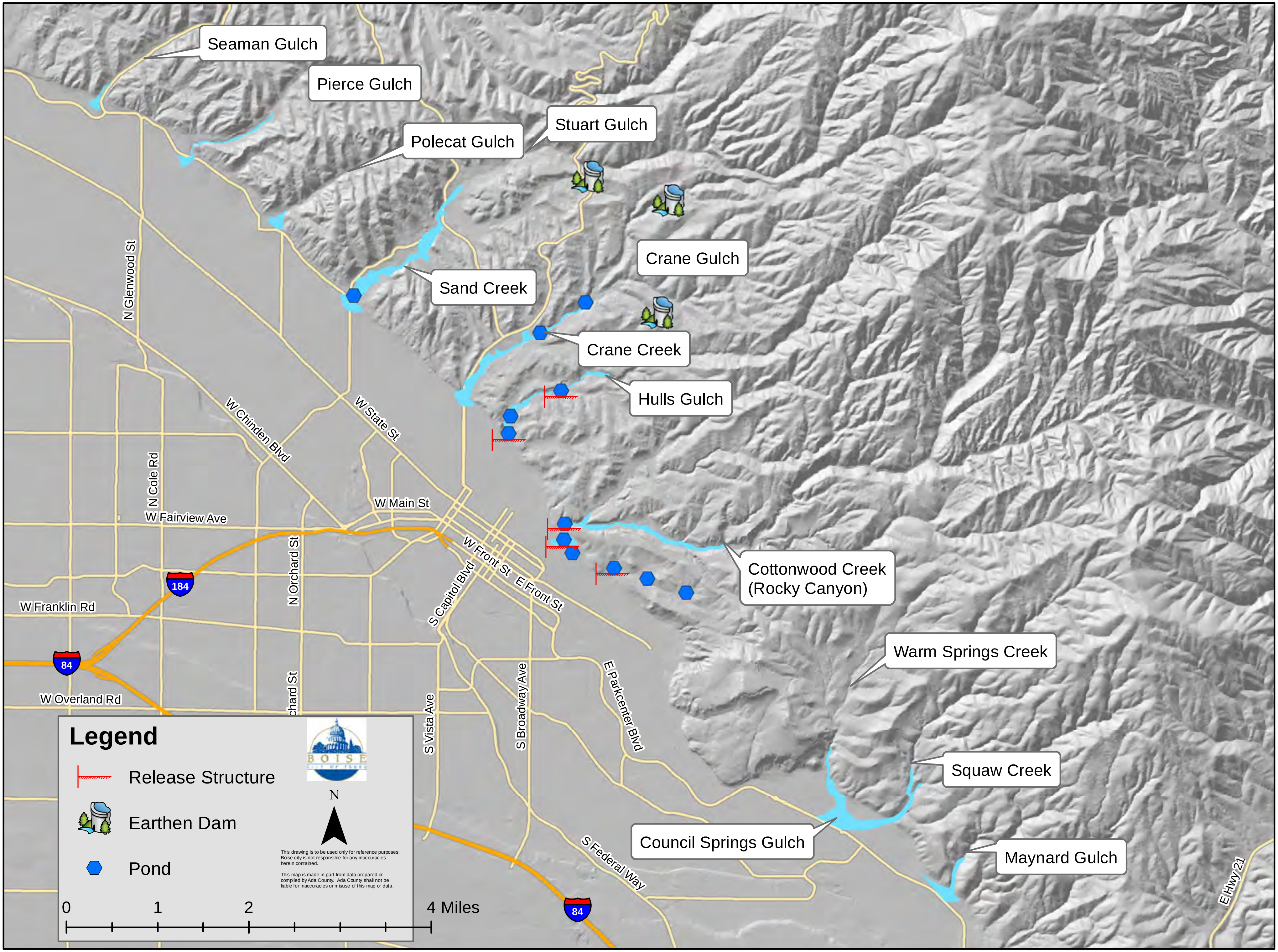
DOCUMENT: Q:\BOISECITY\SWINSP\WORK_IN_PROGRESS\MAP_DOCS\ANNRPT_TLAND2.MXD MAP DATE: 12/12/2017

Supplemental Reapplication Materials

Boise City Structural Flood Controls

City of Boise

Boise Foothills Flood Control Facilities



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Supplemental Reapplication Materials

Garden City MS4 Summary

1. PHYSICAL DESCRIPTION of GARDEN CITY'S MS4

Garden City is located in the Lower Boise River Watershed (Hydraulic Unit Code 17050114) in southwest Idaho. According to the United States 2010 Census Bureau, the City serves a population of 10,972 people. Garden City limits are within the Boise metro area in Ada County, with the City's eastern boundary at West Main Street in Boise and the western boundary at Horseshoe Bend Road near Eagle. The southern boundary and northern boundary parallels Chinden Boulevard and the Boise River/State Street respectively.

2.1 ACHD MS4 in Garden City

All MS4 structures, facilities and outfalls draining public streets and roadways in Garden City are owned and operated by the Ada County Highway District (ACHD). ACHD is responsible for management, maintenance, and monitoring of the MS4; Garden City is responsible for limiting the discharge of pollutants to the portion of the MS4 within Garden City limits. The SWMP control measures designed to accomplish this goal to the Maximum Extent Practicable (MEP) are discussed in *Section 3- Minimum Control Measures*. As noted in the Introduction, an **Intergovernmental Agreement and Operating Guidelines** (Appendix A) have been drafted with ACHD and other permittees to establish the roles and responsibilities of each entity under the NPDES Municipal Stormwater Permit.

These responsibilities are further defined in the document titled "Interagency Agreement for the Inspection, Monitoring and Enforcement of Industrial & Commercial High Risk Runoff". This document, which is an agreement between ACHD and Garden City, also included in Appendix A.

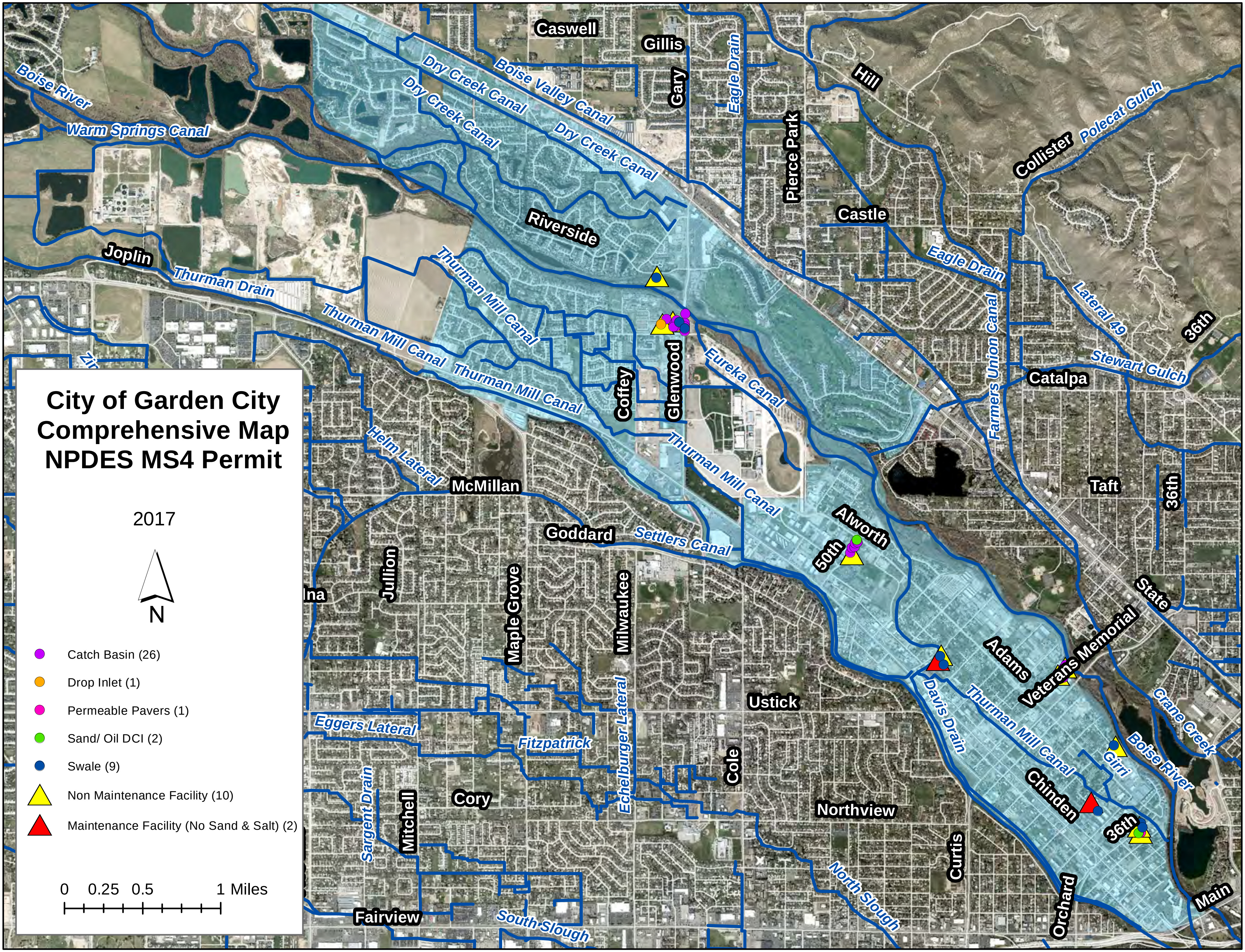
2.2 Garden City MS4

During FY 2015, the City disconnected all City owned and operated MS4 outfalls and now retains all stormwater onsite in newly constructed stormwater structure and controls. Please refer to *section 3.2.7 Outfall Disconnection* for details.

Garden City owns and operates various facilities and parks which have onsite retention and permanent stormwater controls. These facilities are limited in their pollutant loading potential to the MS4 owned by the ACHD and are not connected to any outfalls to the Boise River. All City properties and structures are inspected annually to check for any maintenance that is needed and also to evaluate the potential for discharge of pollutants to the MS4. An inventory of facilities owned by the City and related management and maintenance activities are described in detail in SWMP *section* 3.5 *Stormwater Infrastructure and Street Management*.

Supplemental Reapplication Materials

Garden City Inventory Map


City of Garden City
Comprehensive Map
NPDES MS4 Permit
2017
N
Catch Basin (26)
Drop Inlet (1)
Permeable Pavers (1)
Sand/ Oil DCI (2)
Swale (9)
Non Maintenance Facility (10)
Maintenance Facility (No Sand & Salt) (2)
0 0.25 0.5 1 Miles
Caswell
Gillis
Gary
Eagle Drain
Boise River
Warm Springs Canal
Dry Creek Canal
Dry Creek Canal
Boise Valley Canal
Dry Creek Canal
Hill
Pierce Park
Collister
Polecat Gulch
Castle
Riverside
Joplin
Thurman Drain
Thurman Mill Canal
Thurman Mill Canal
Thurman Mill Canal
Eagle Drain
Lateral 49
36th
Farmers Union Canal
Stewart Gulch
Catalpa
Eureka Canal
Coffey
Glenwood
Thurman Mill Canal
Helm Lateral
McMillan
Taft
36th
Alworth
Goddard
Settlers Canal
50th
Julion
Maple Grove
Milwaukee
State
Adams
Veterans Memorial
Ustick
Eggers Lateral
Fitzpatrick
Echelburger Lateral
Davis Drain
Thurman Mill Canal
Crane Creek
Girri
Boise River
Cole
Chinden
Cory
Northview
36th
Sargent Drain
Mitchell
Curtis
North Slough
Orchard
Main
Fairview
South Slough

Supplemental Reapplication Materials

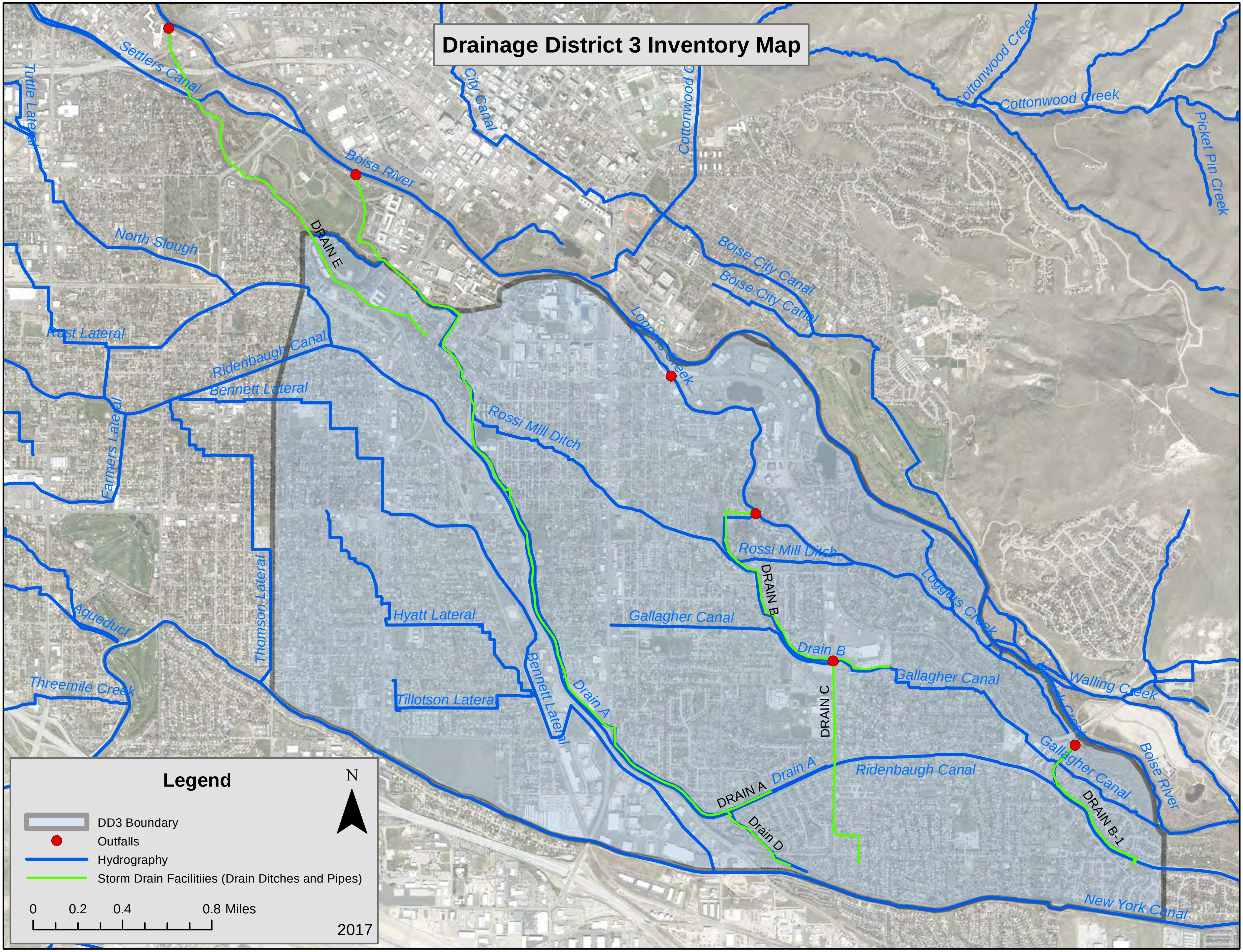
Drainage District 3 MS4 Summary

Map Description

Ada County Drainage District No. 3 (the “District”) has provided a map and other supporting material which shows the several drains under the control and jurisdiction of the District. These drains receive discharges from several irrigation facilities, storm drainage from various sources, as well as municipal water discharge. The mapping includes the boundary line of the District, seven drainage facilities, and four outfall locations with an additional two outfall locations. Discharge pipes and facilities into the District system are also shown.

Supplemental Reapplication Materials

Drainage District 3 Inventory Map


Drainage District 3 Inventory Map
Settlers Canal
Tuttle Lateral
City Canal
Cottonwood Creek
Cottonwood Creek
Picket Pin Creek
Boise River
North Slough
DRAIN E
Boise City Canal
Boise City Canal
Loggers Creek
Rust Lateral
Ridenbaugh Canal
Bennett Lateral
Farmers Lateral
Rossi Mill Ditch
Rossi Mill Ditch
DRAIN B
Loggers Creek
Gallagher Canal
Hyatt Lateral
Thomson Lateral
Aqueduct
Drain B
Gallagher Canal
Walling Creek
Threemile Creek
Tillotson Lateral
Bennett Lateral
Drain A
DRAIN C
Gallagher Canal
Boise River
Drain A
DRAIN A
Ridenbaugh Canal
Drain D
DRAIN B-1
New York Canal
Legend
N
DD3 Boundary
Outfalls
Hydrography
Storm Drain Facilitiies (Drain Ditches and Pipes)
0 0.2 0.4 0.8 Miles
2017

Supplemental Reapplication Materials

Idaho Transportation Department MS4 Summary

The Idaho Transportation Department District 3 (ITD) has jurisdiction of the Municipal Separate Storm Sewer System (MS4) on the Interstate and State Highways within the Boise City Limits for the Phase I MS4 Permit. ITD facilities within the Phase I Permit area are I-84, I-184, US 20/26, State Highway 44, State Highway 55, and State Highway 21.

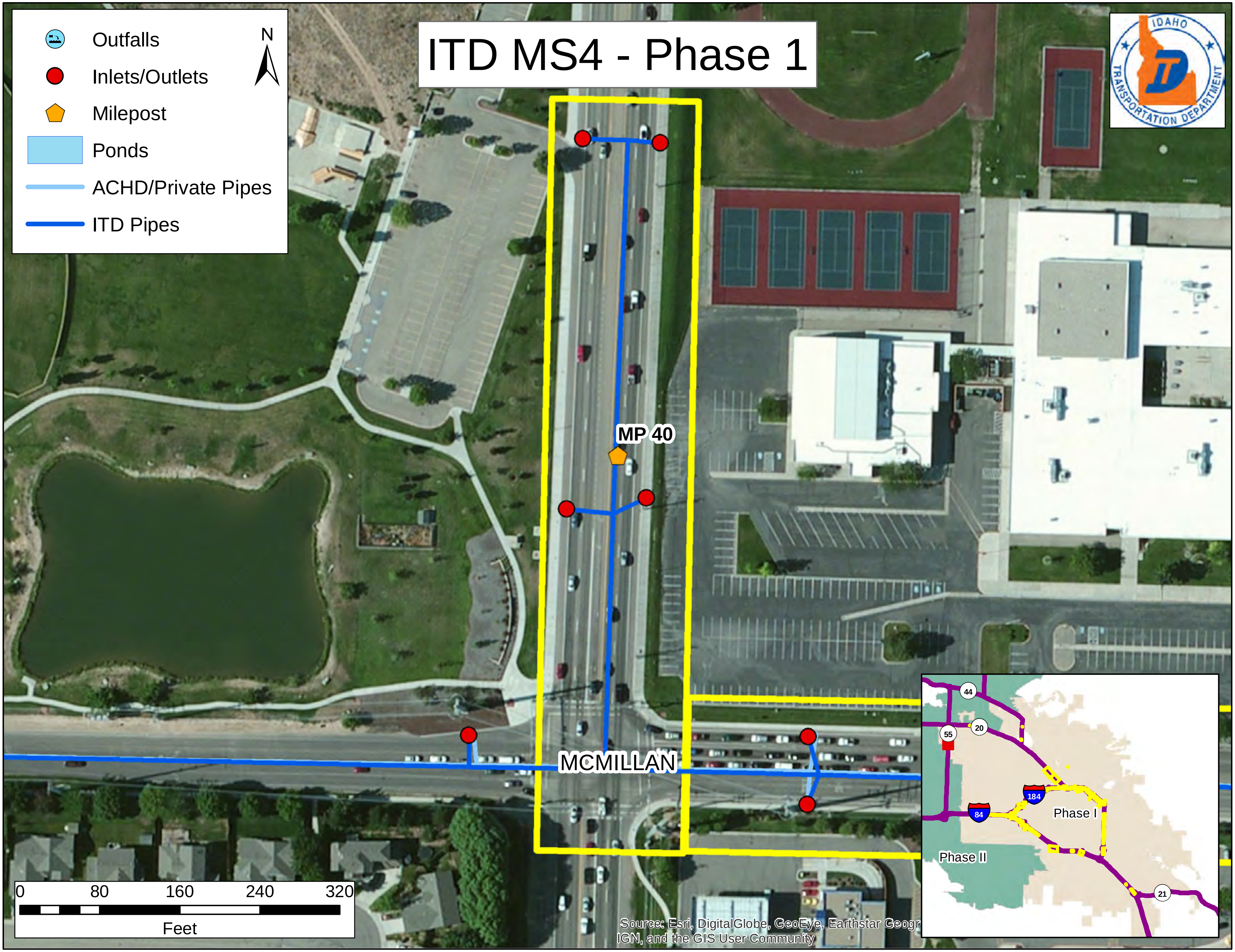
The storm sewer system inventory map of the Idaho Transportation Department District 3 (ITD) (Figure 1) is an overview of ITD's storm sewer system facilities including those areas ITD is responsible for within the MS4 Phase I permit area. Table 1 below provides characteristics of the ITD MS4 system. For detail please refer to the geographic information system map book provided in Appendix C. The map book indicates locations where ITD's system is physically connected to another entity's system, names the receiving waters, identifies subwatersheds, and locates our maintenance facilities.

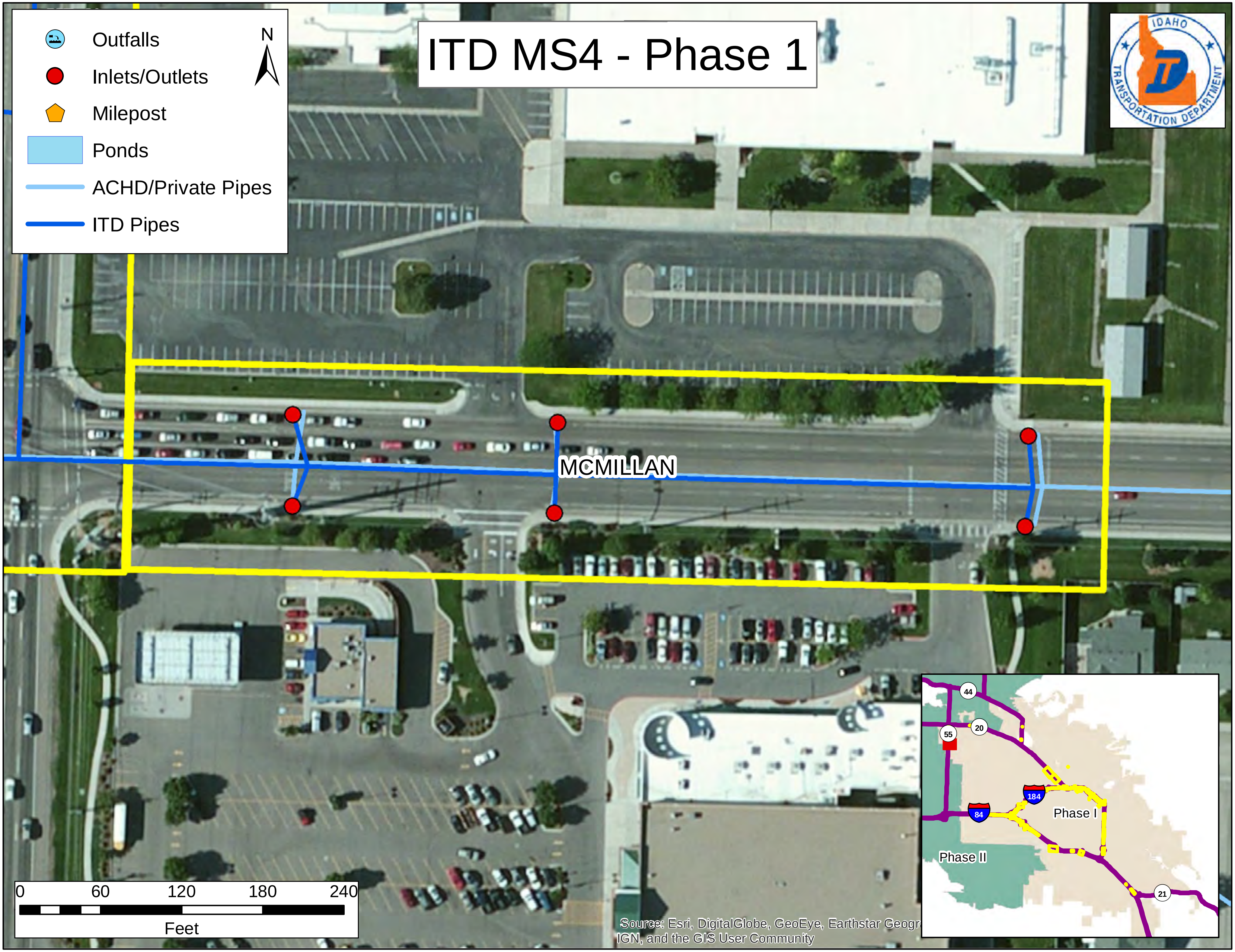
TABLE 1: ITD's MS4 Characteristics:

Structures	Quantities
Pipe	28 miles
Inlets	939
Outfalls	16
Structural Treatment Devices/Ponds	3
Maintenance Facilities	2

Supplemental Reapplication Materials

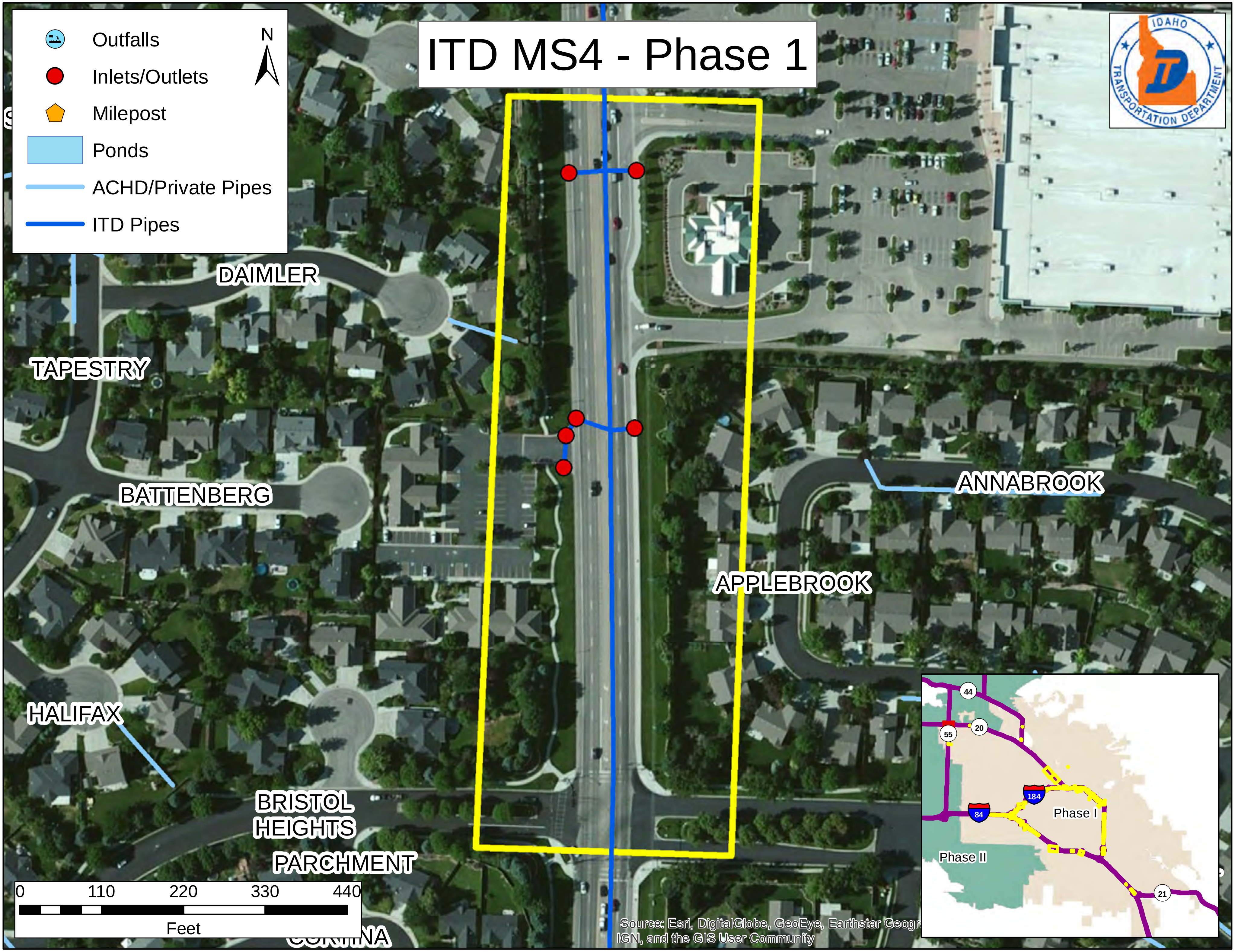
Idaho Transportation Department Inventory Map


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
MP 40
MCMILLAN
0
80
160
240
320
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
21
Phase I
Phase II
Datum: NAD83

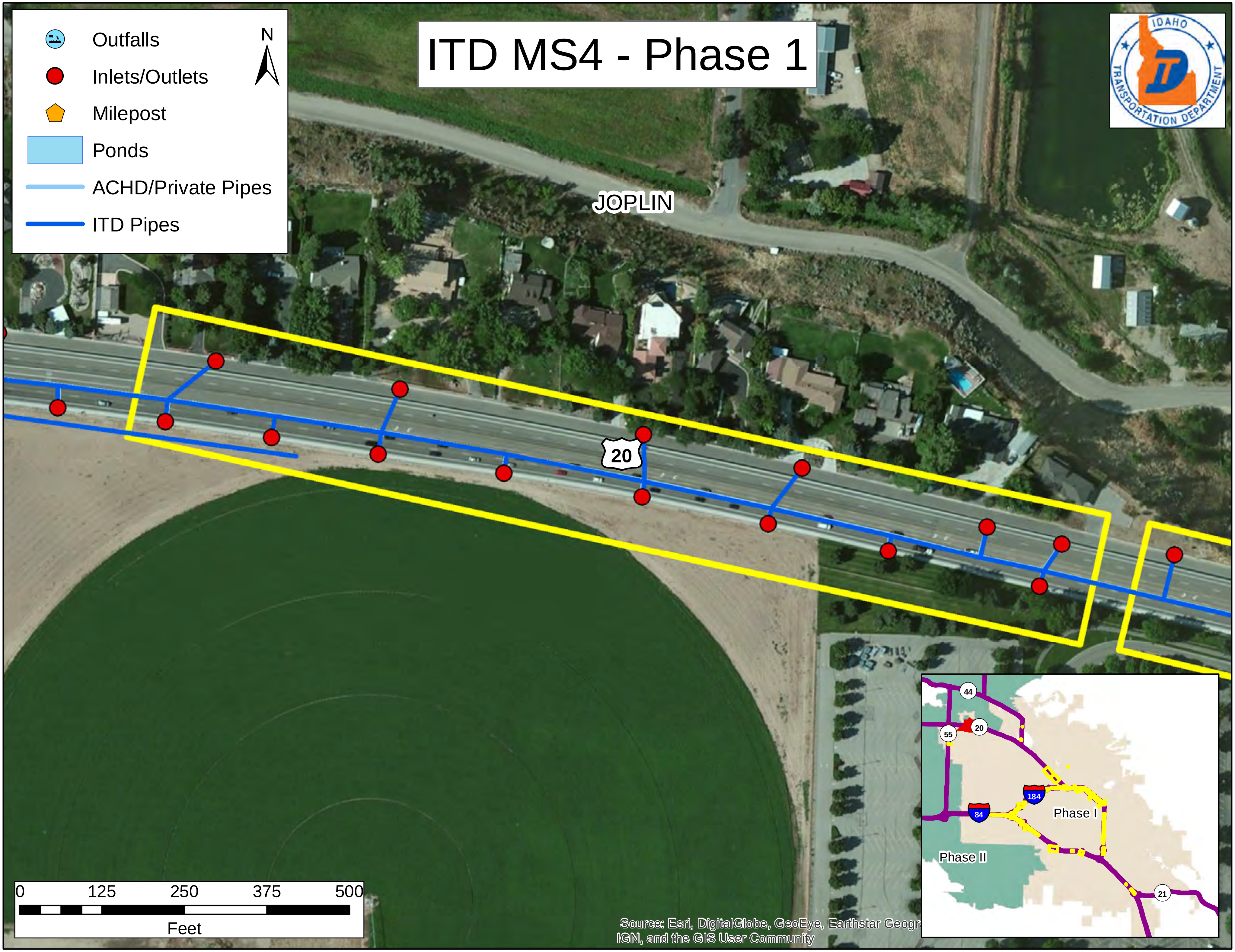


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
MCMILLAN
0
60
120
180
240
Feet
44
20
55
184
84
21
Phase I
Phase II
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

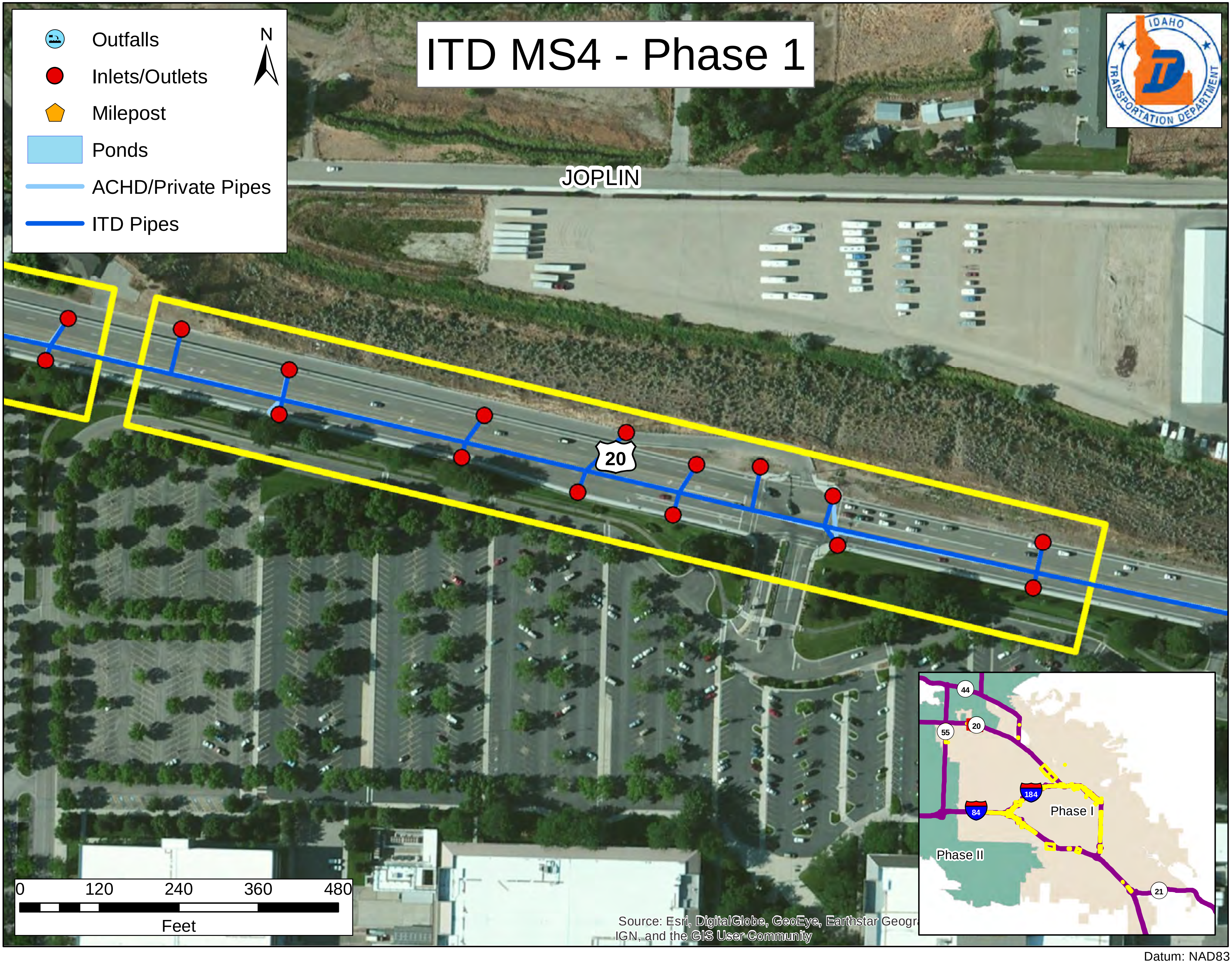
Datum: NAD83

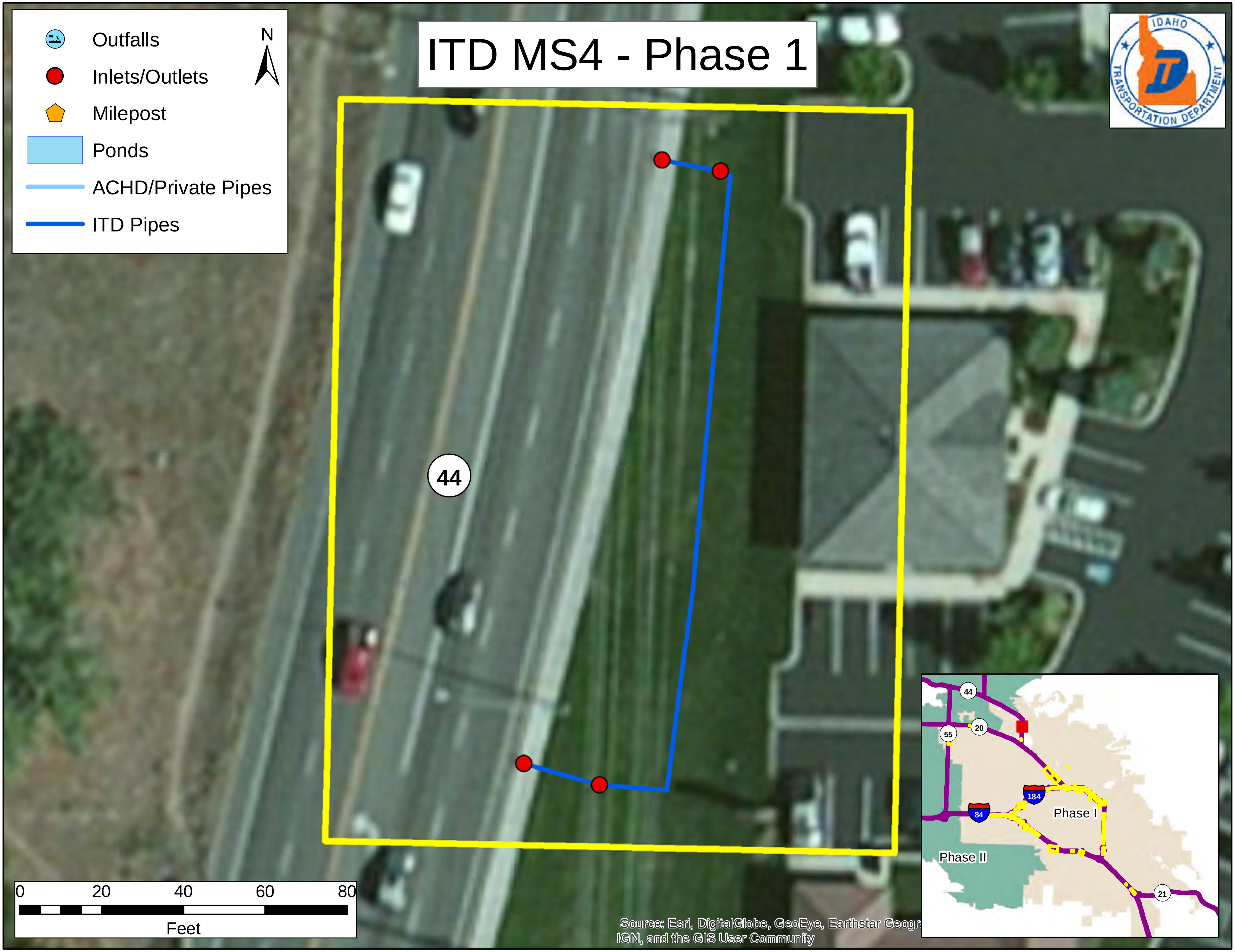

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
DAIMLER
TAPESTRY
BATTENBERG
ANNABROOK
APPLEBROOK
HALIFAX
BRISTOL HEIGHTS
PARCHMENT
0
110
220
330
440
Feet
Phase I
Phase II
44
20
55
184
84
21
IDAHO TRANSPORTATION DEPARTMENT
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
JOPLIN
20
0 125 250 375 500
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

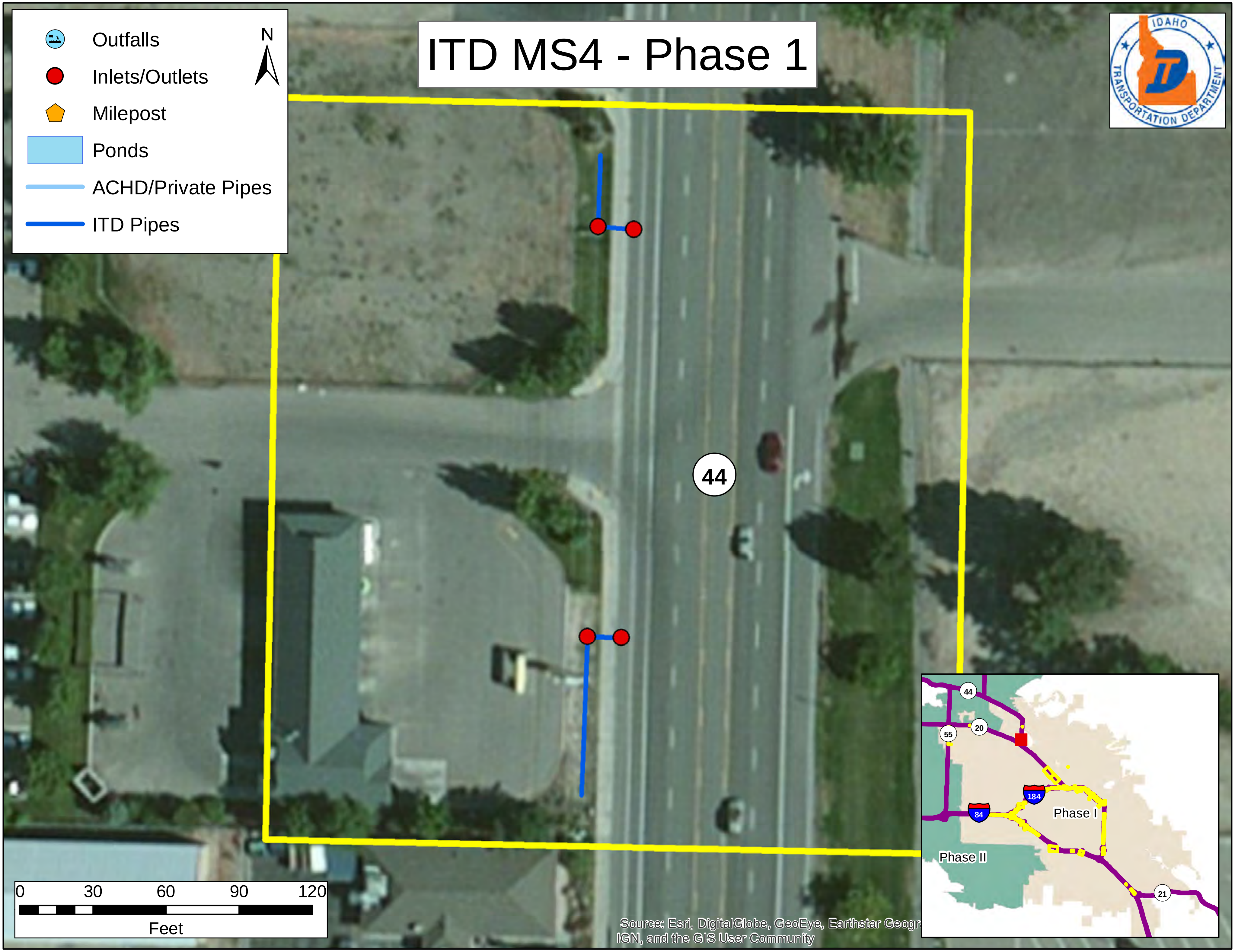
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
JOPLIN
20
0
120
240
360
480
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21
Datum: NAD83

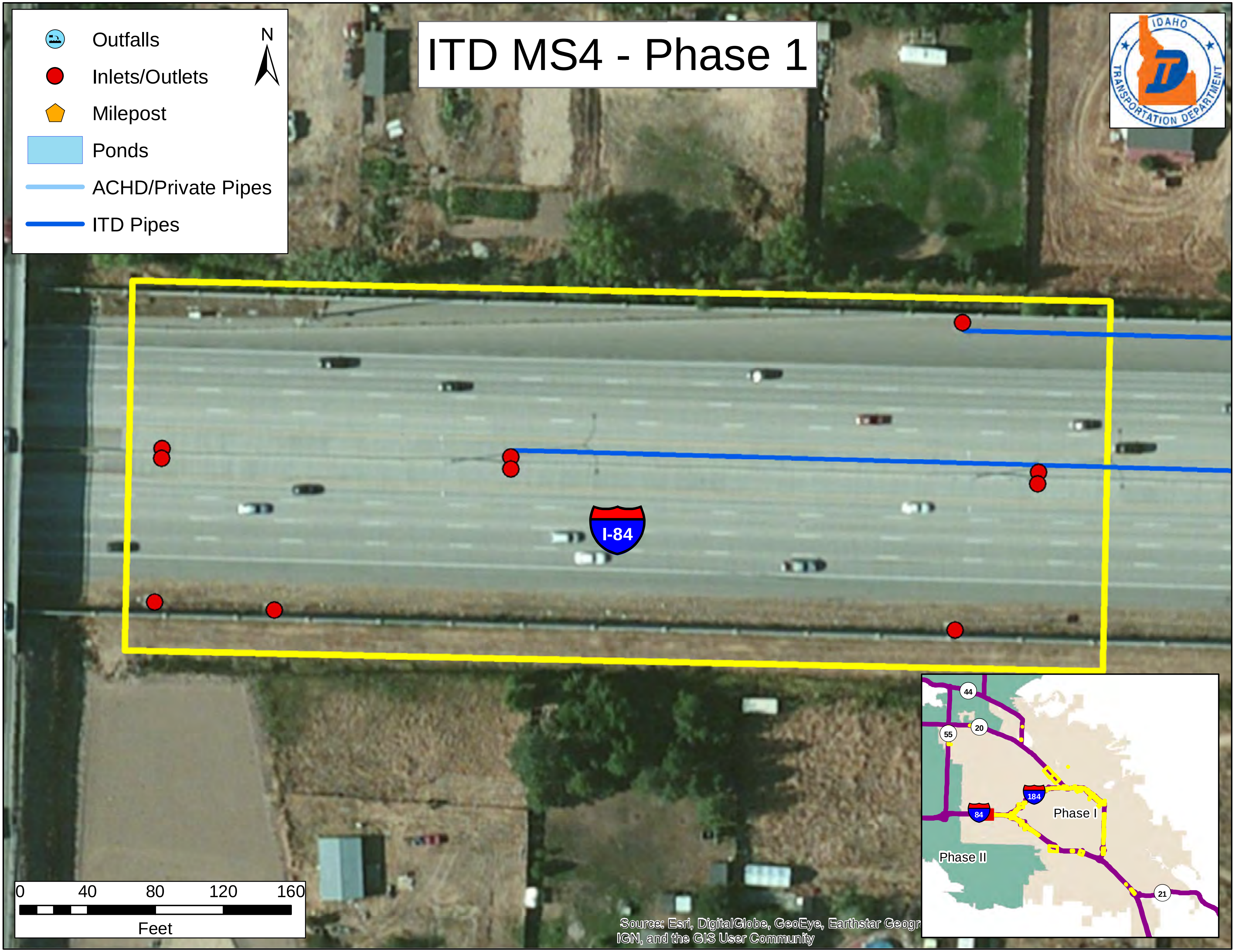


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
44
0
20
40
60
80
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

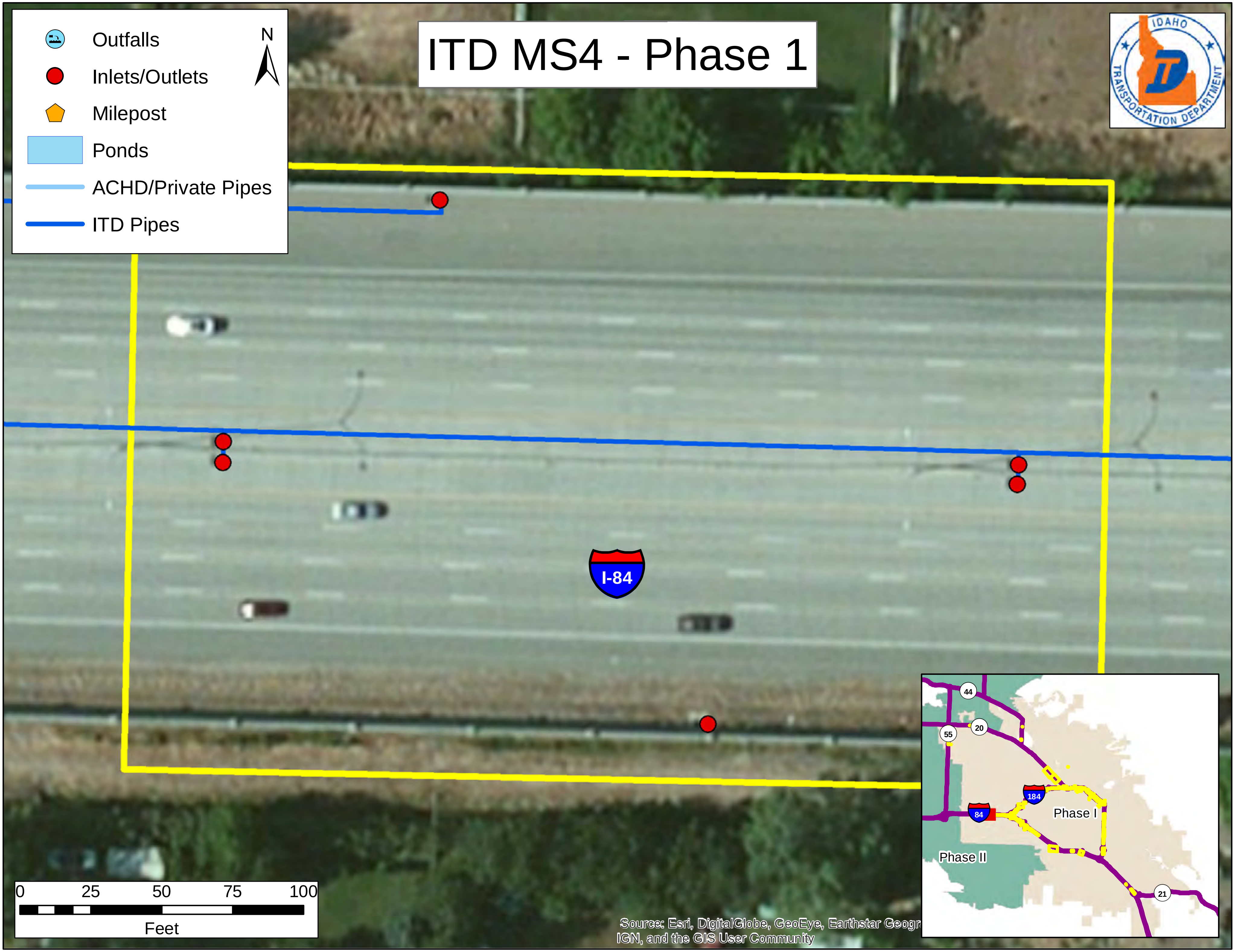
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
44
0
30
60
90
120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
21
Phase I
Phase II

Datum: NAD83

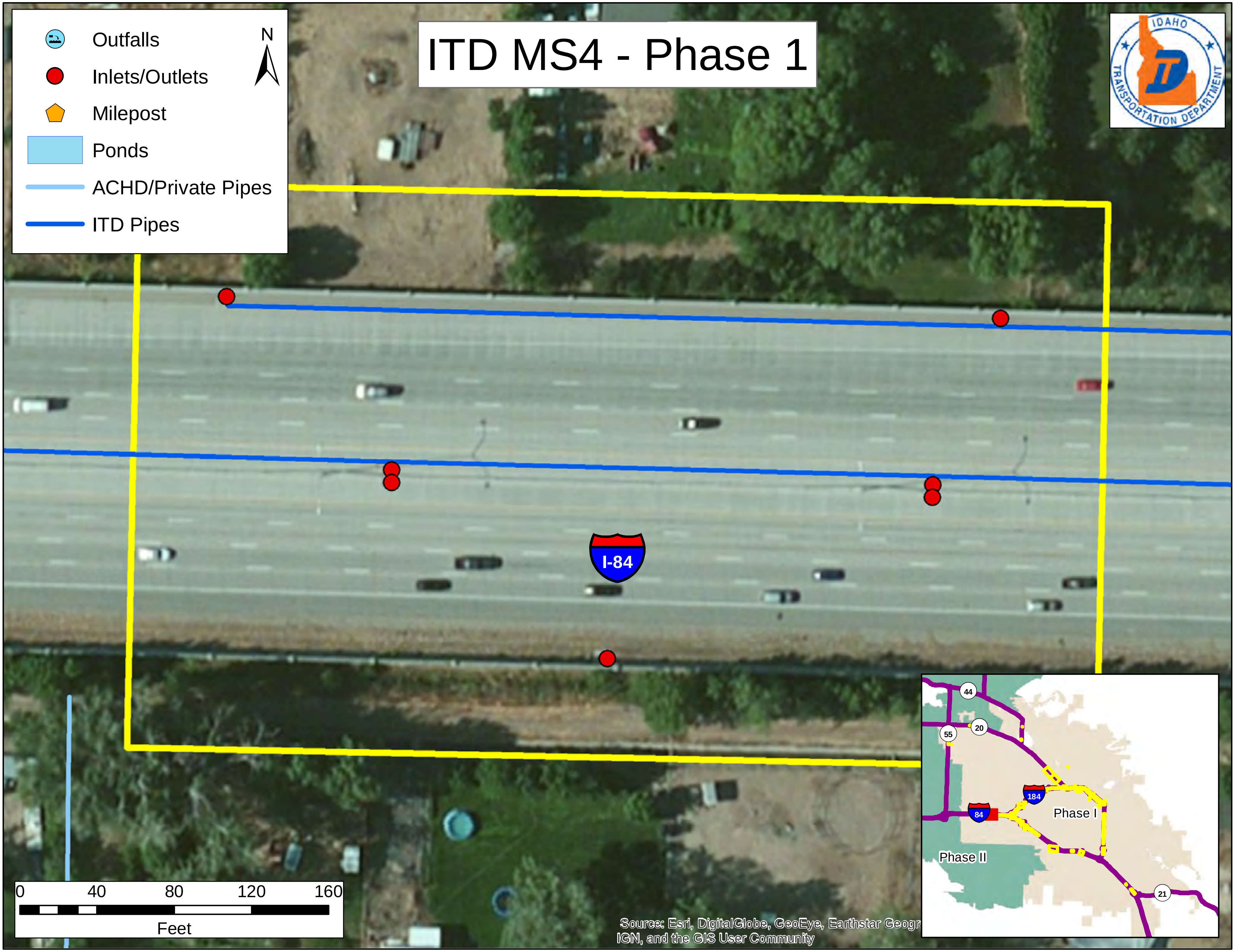

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
I-84
0 25 50 75 100
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-84
0
40
80
120
160
Feet
44
20
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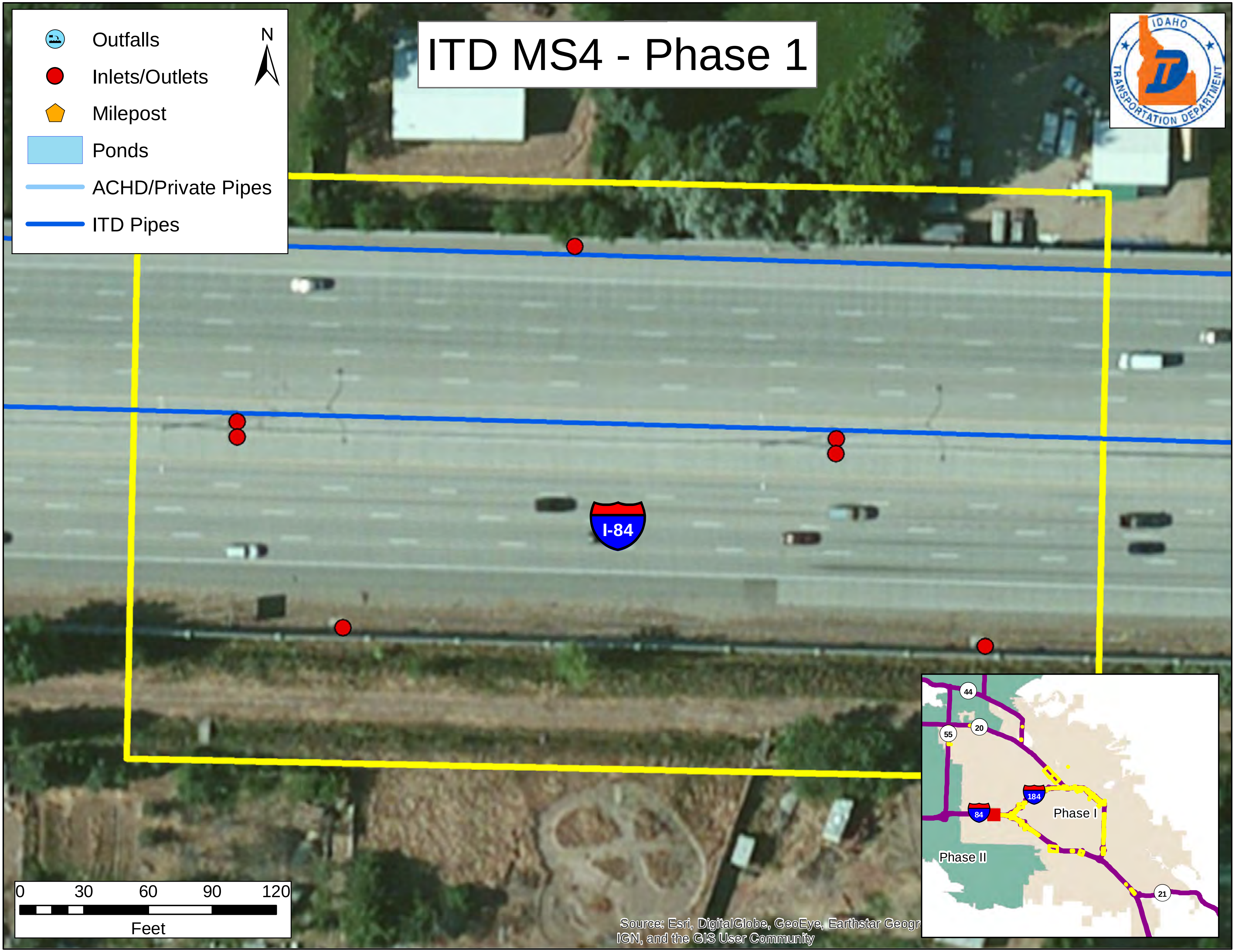
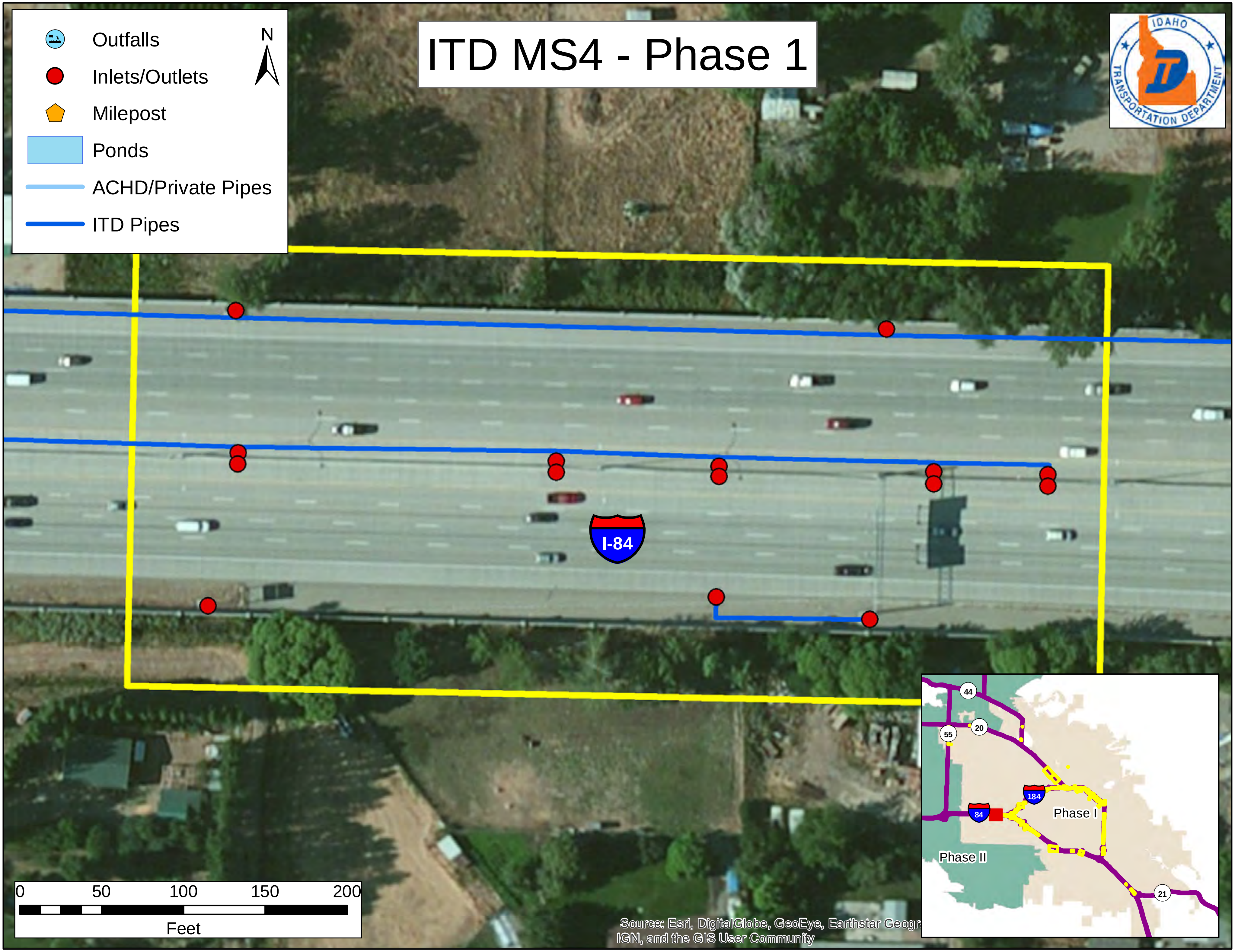
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

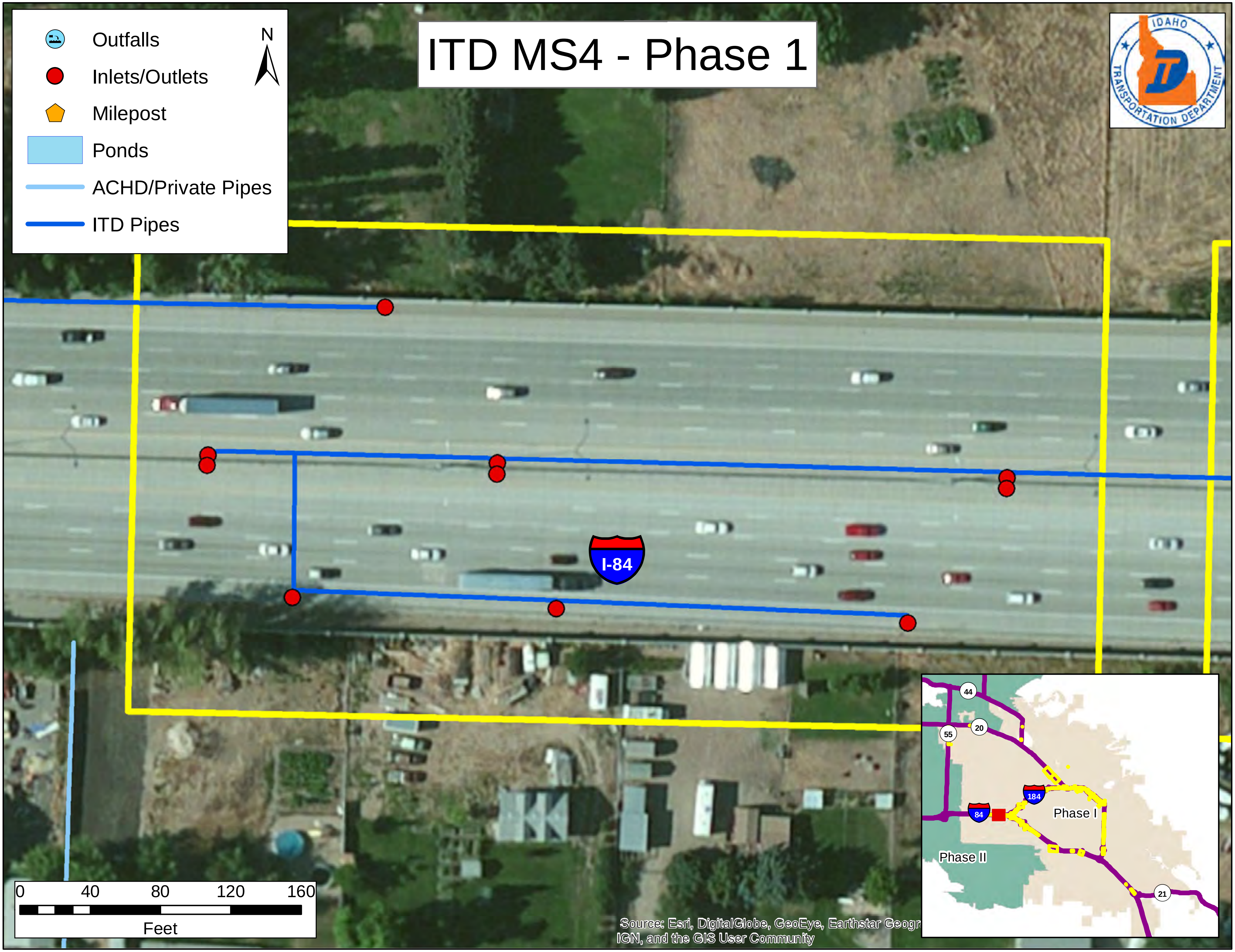
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-84
44
20
55
184
84
Phase I
Phase II
21
0 30 60 90 120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Datum: NAD83



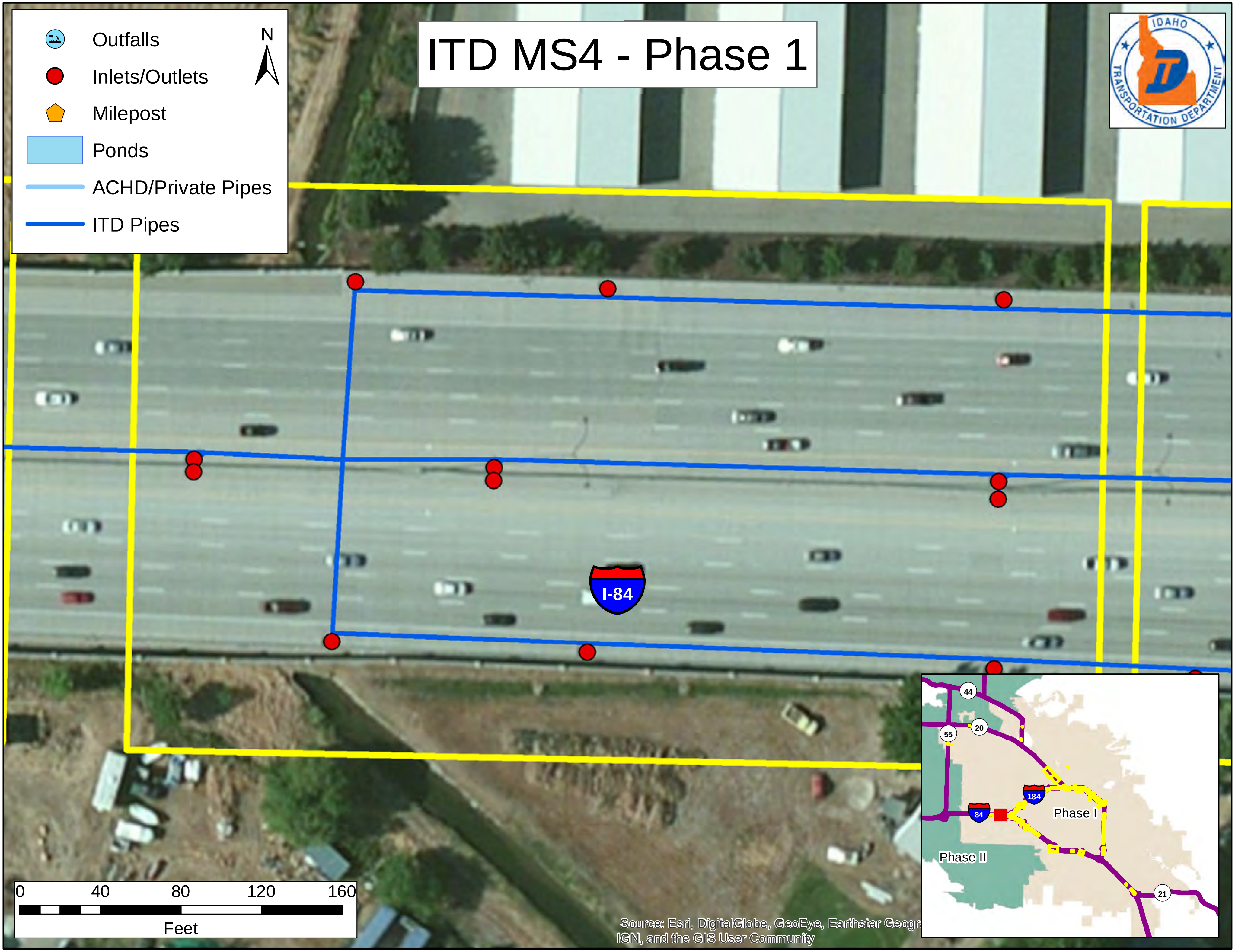
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
I-84
44
20
55
184
84
Phase I
Phase II
21
0 50 100 150 200
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83

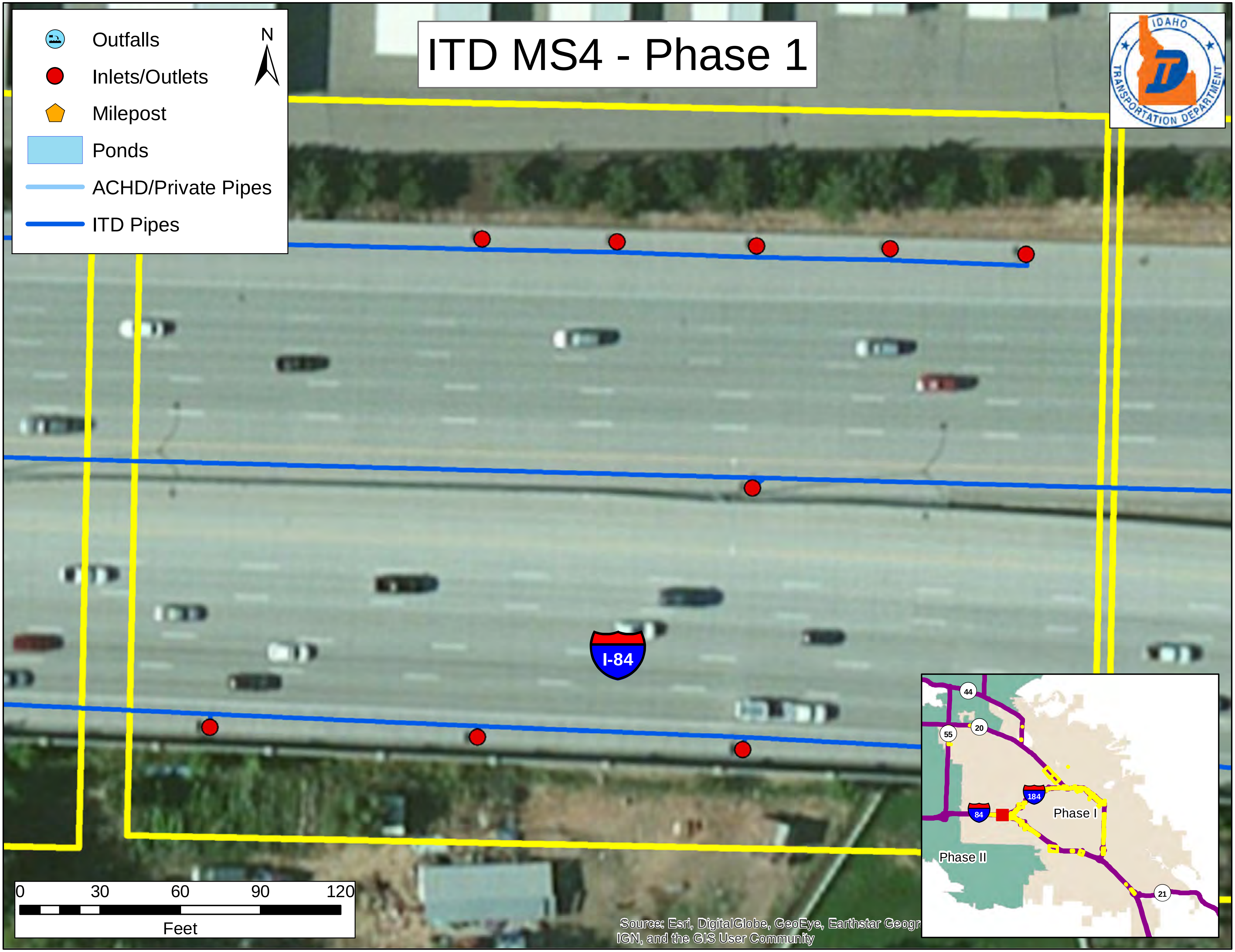


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
0
40
80
120
160
Feet
44
20
55
184
84
Phase I
Phase II
21
IGN, and the GIS User Community

Datum: NAD83

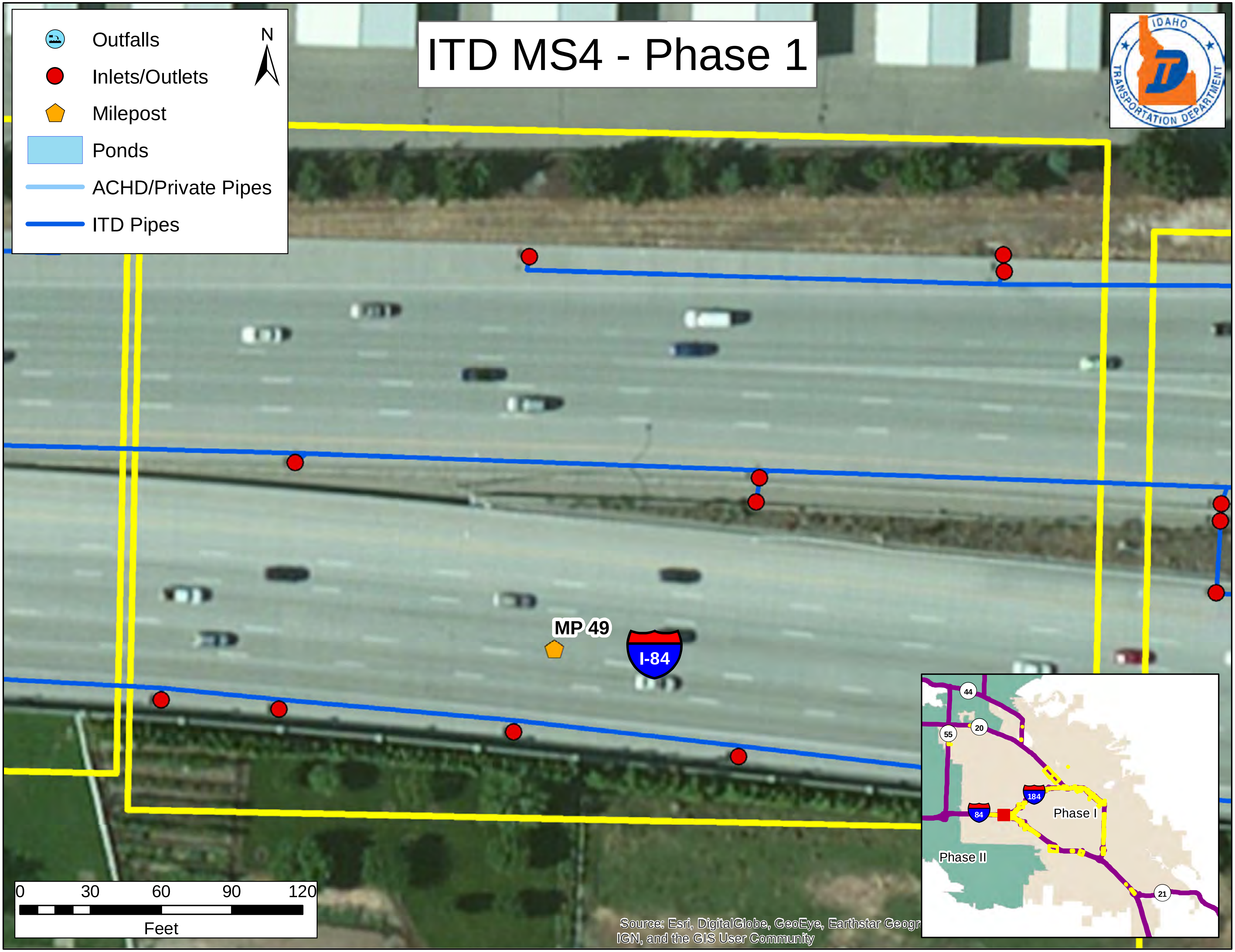


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
Datum: NAD83

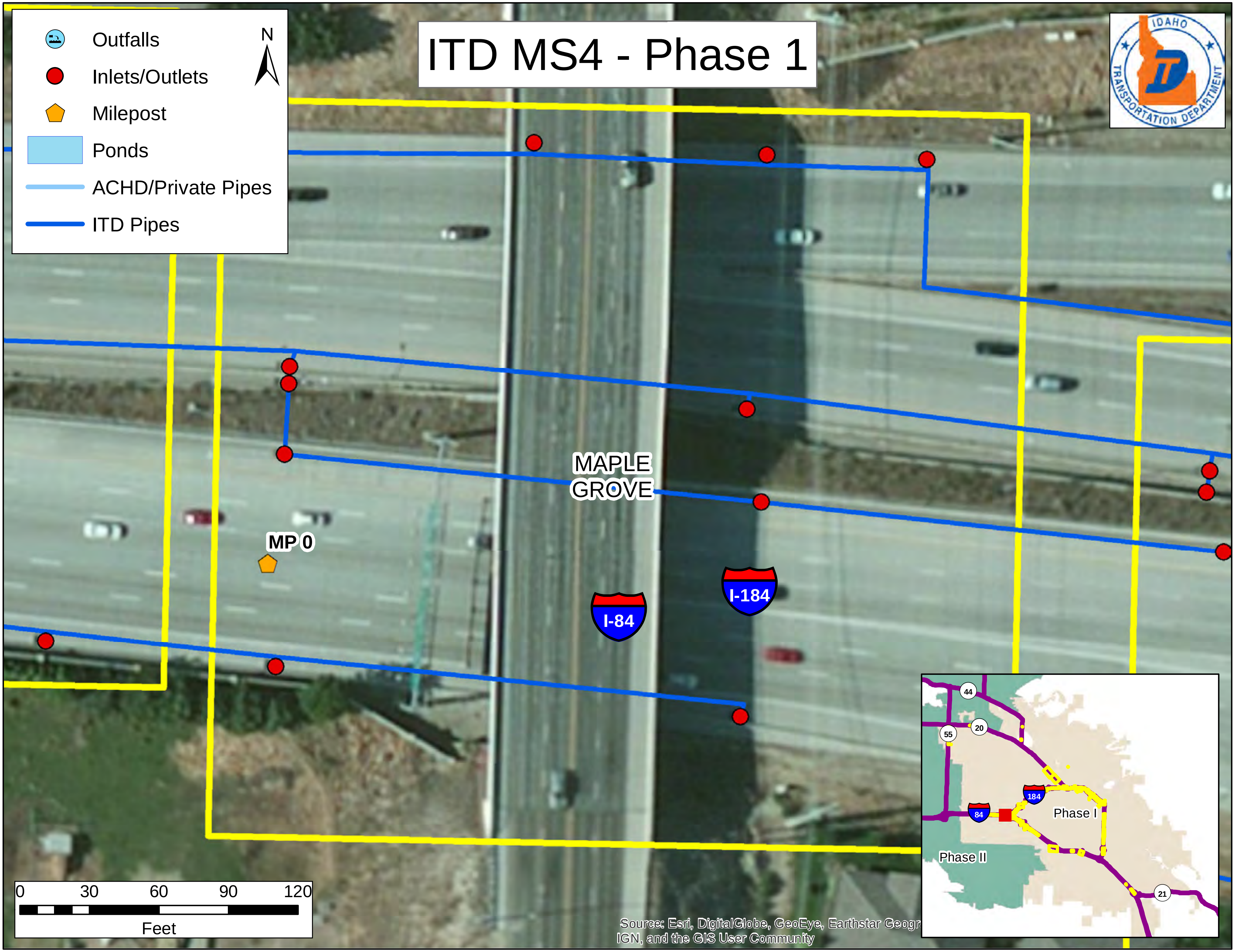


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
0 30 60 90 120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83

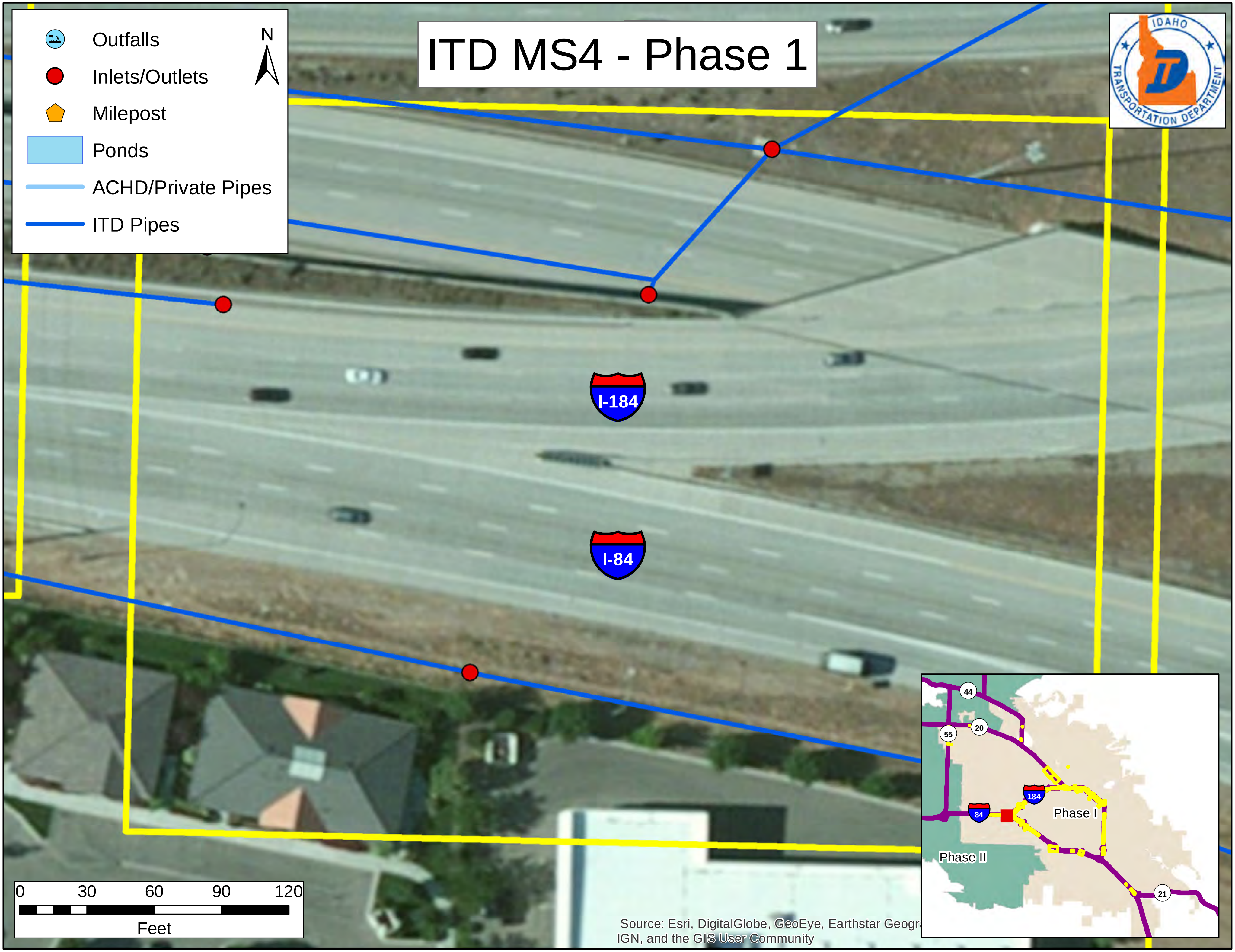

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
MP 49
I-84
0 30 60 90 120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



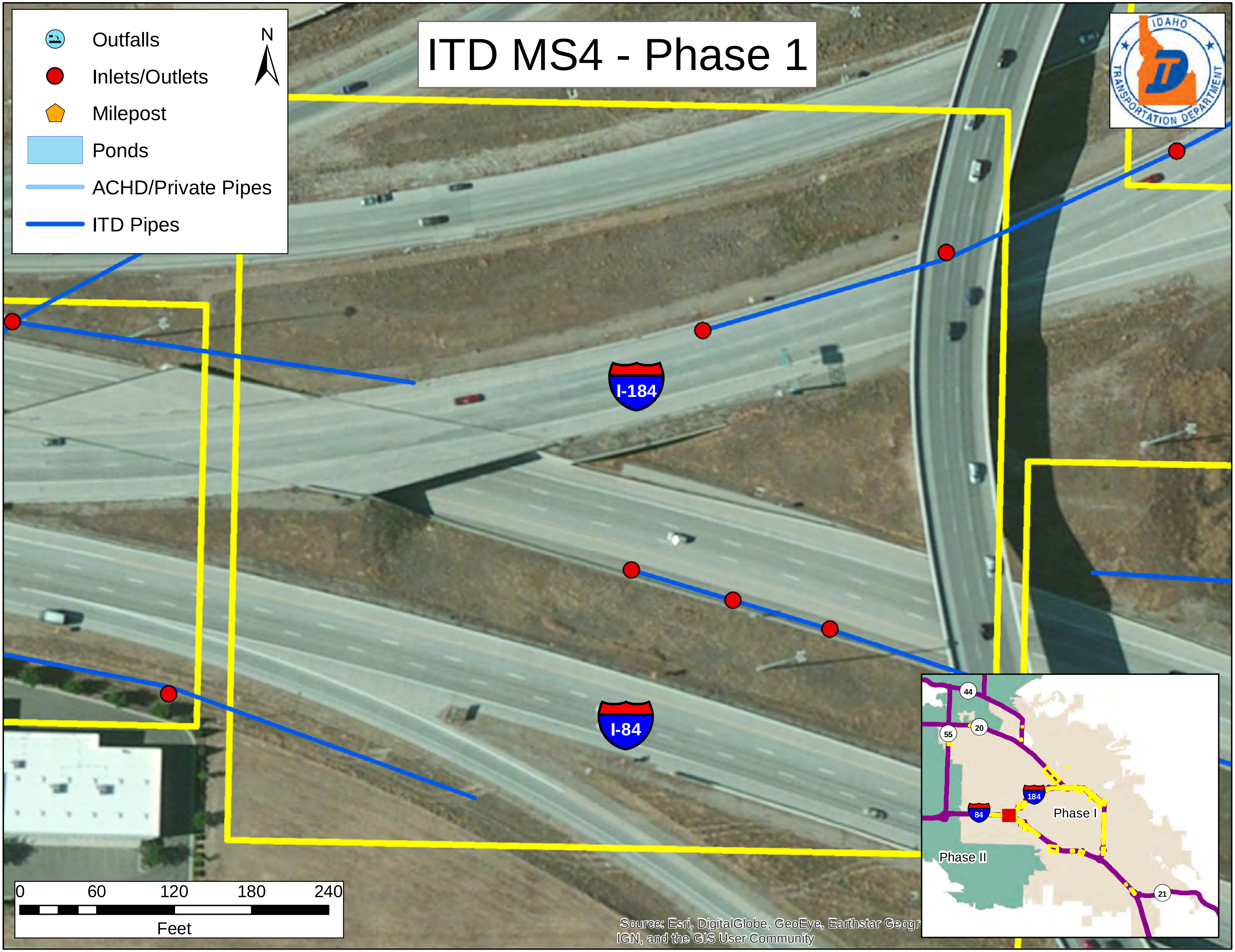
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
MAPLE GROVE
MP 0
I-84
I-184
0
30
60
90
120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

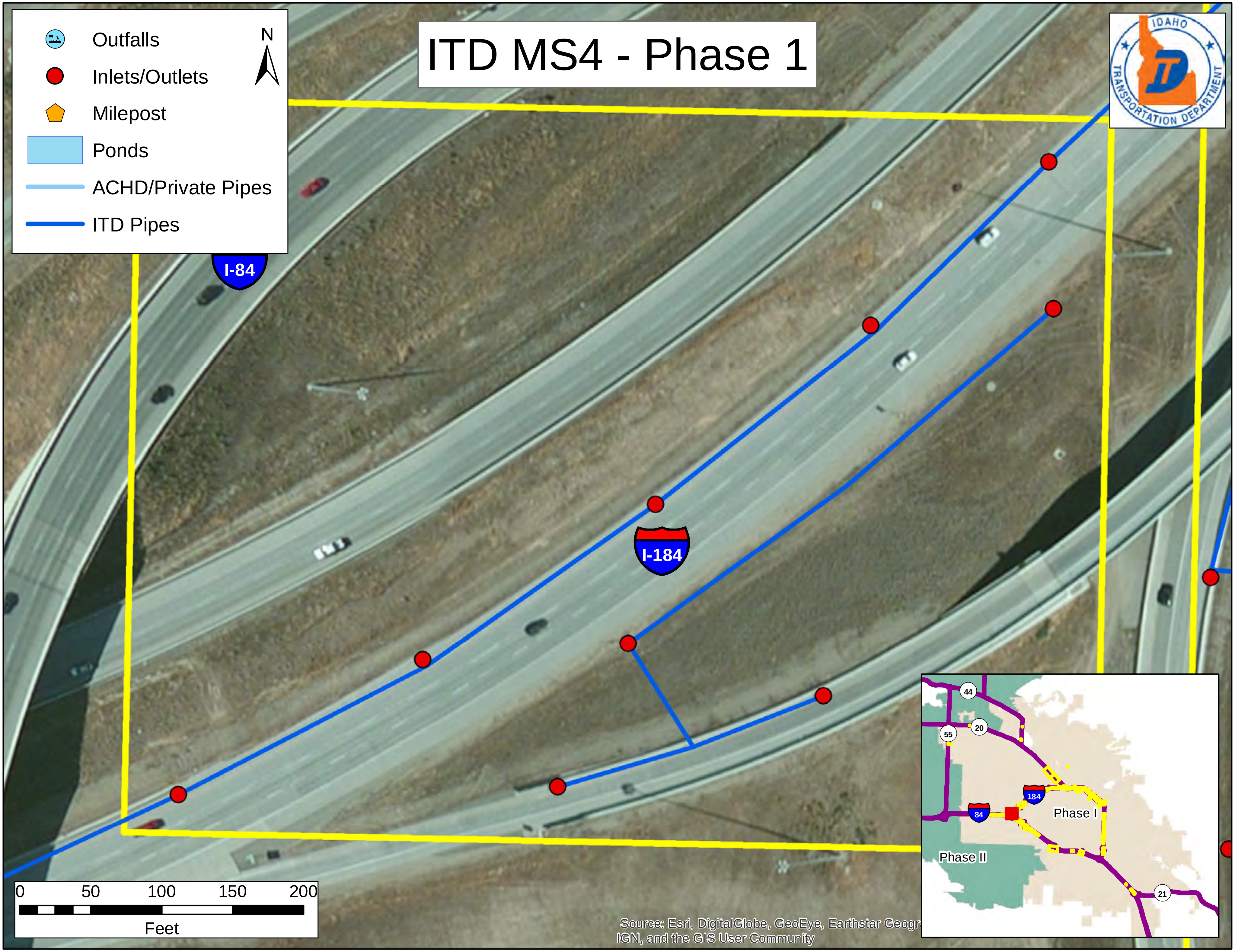


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-184
I-84
0 30 60 90 120
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogra
IGN, and the GIS User Community

Datum: NAD83

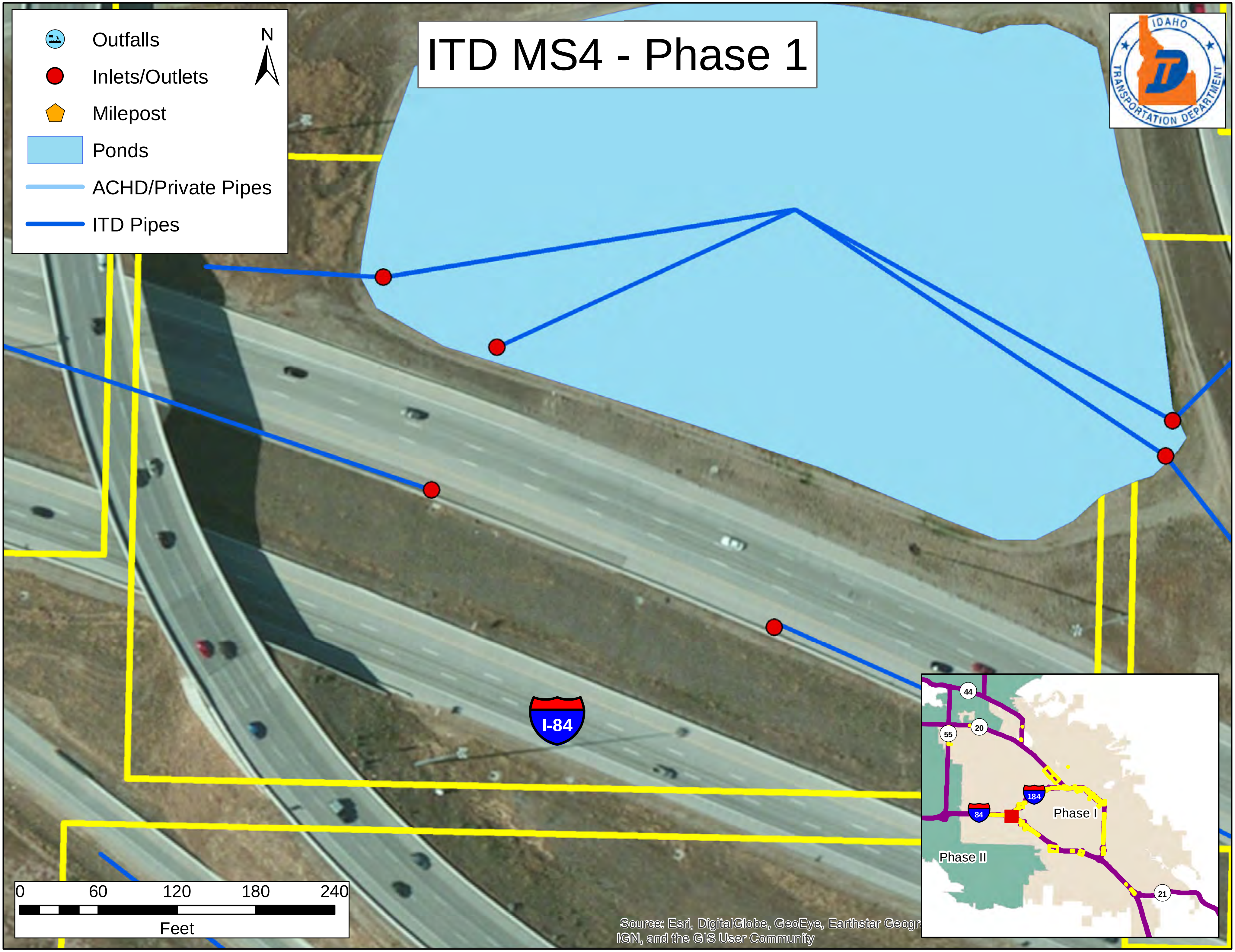

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-184
I-84
0
60
120
180
240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

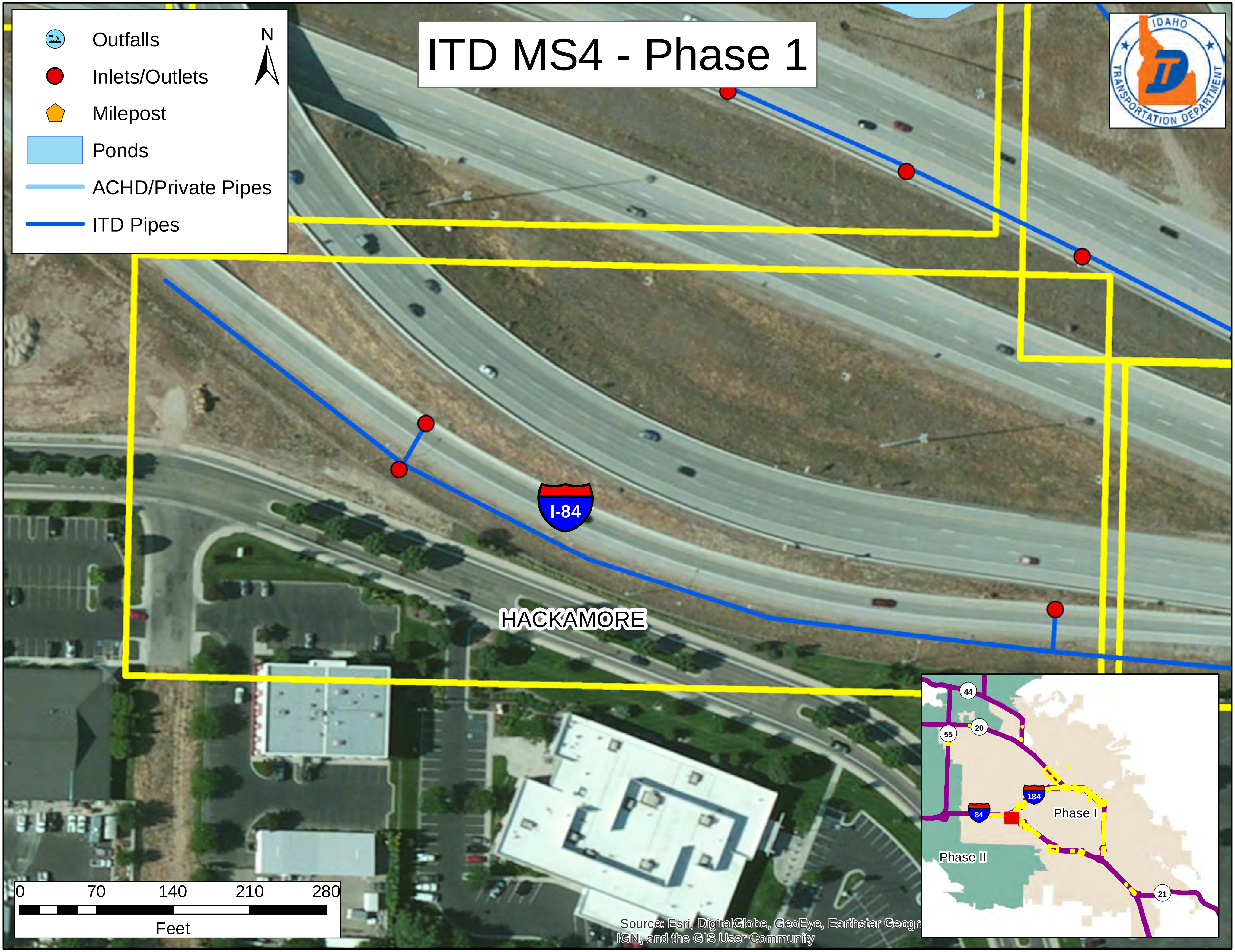


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
I-184
0 50 100 150 200
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

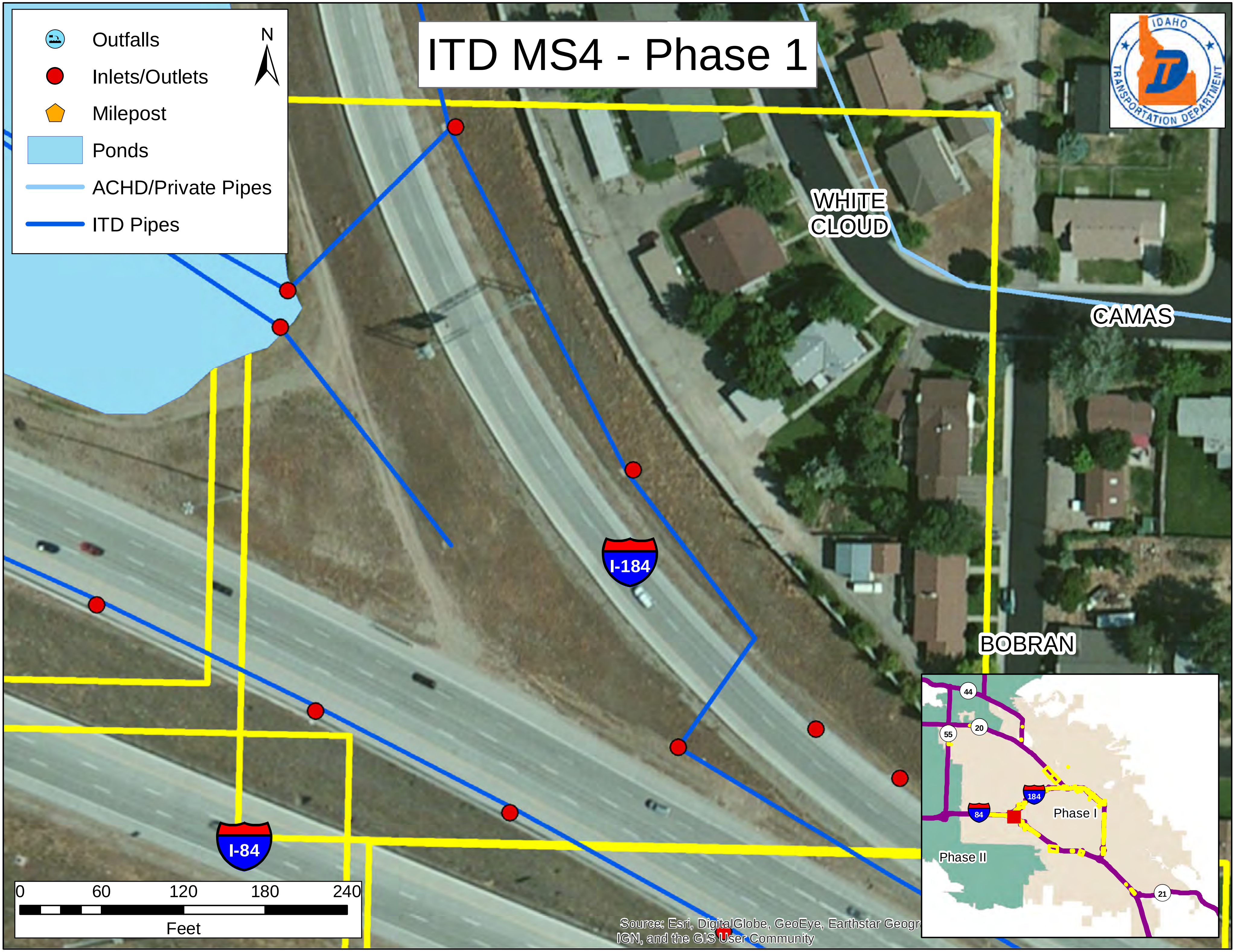
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
0 60 120 180 240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83

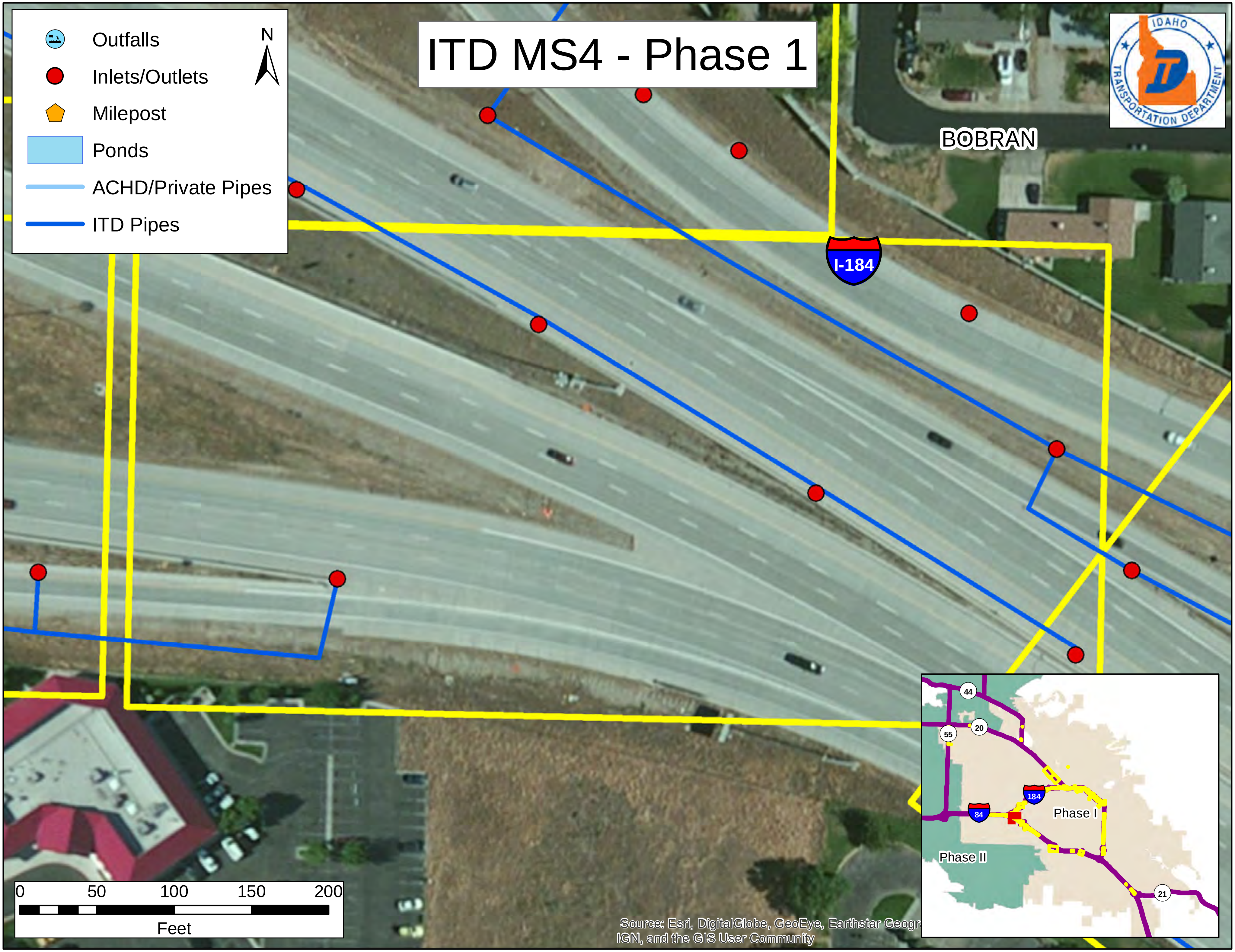

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-84
HACKAMORE
0 70 140 210 280
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
WHITE CLOUD
CAMAS
BOBRAN
I-184
I-84
0
60
120
180
240
Feet
44
20
55
184
84
21
Phase I
Phase II
IDAHO TRANSPORTATION DEPARTMENT
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83

ITD MS4 - Phase 1



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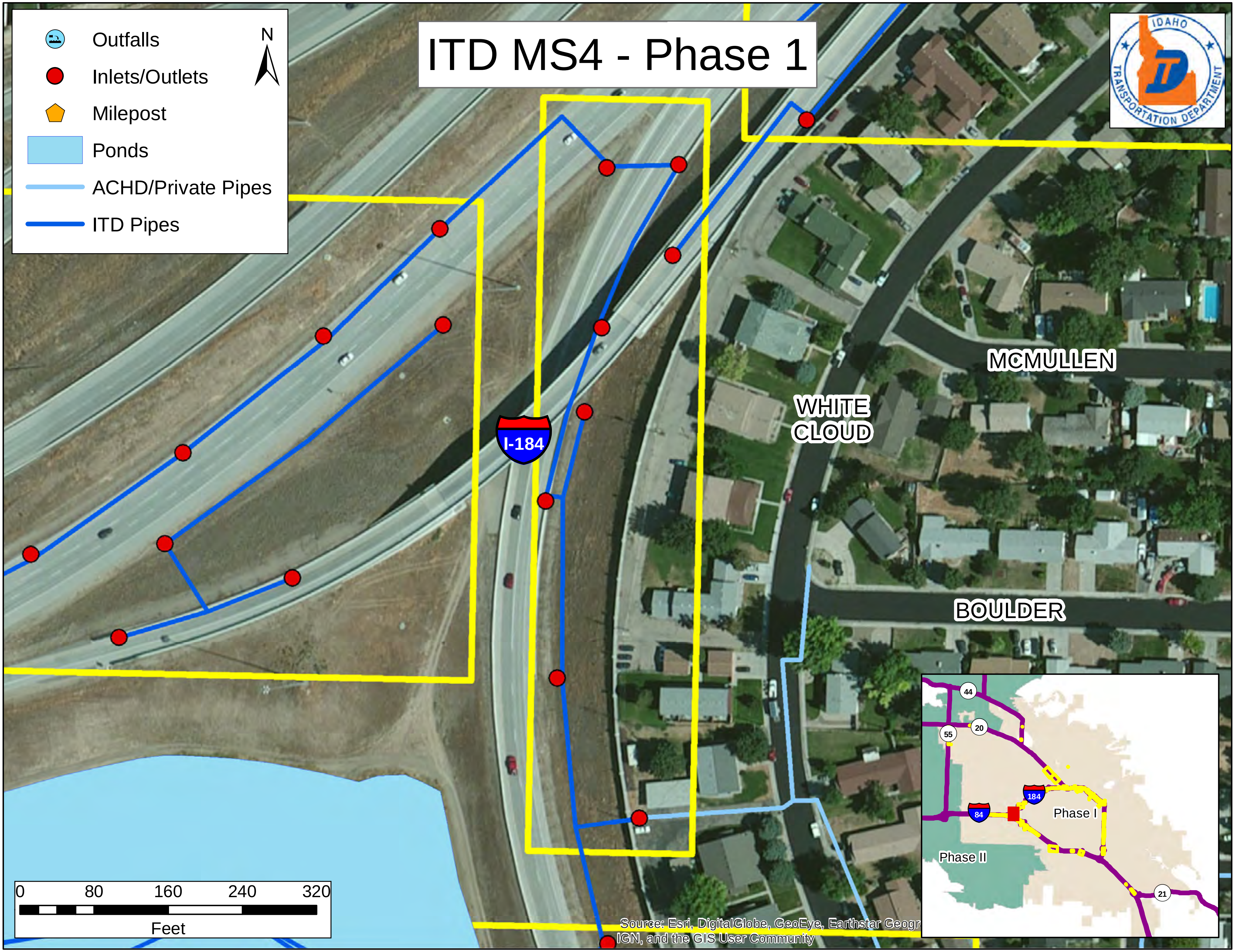
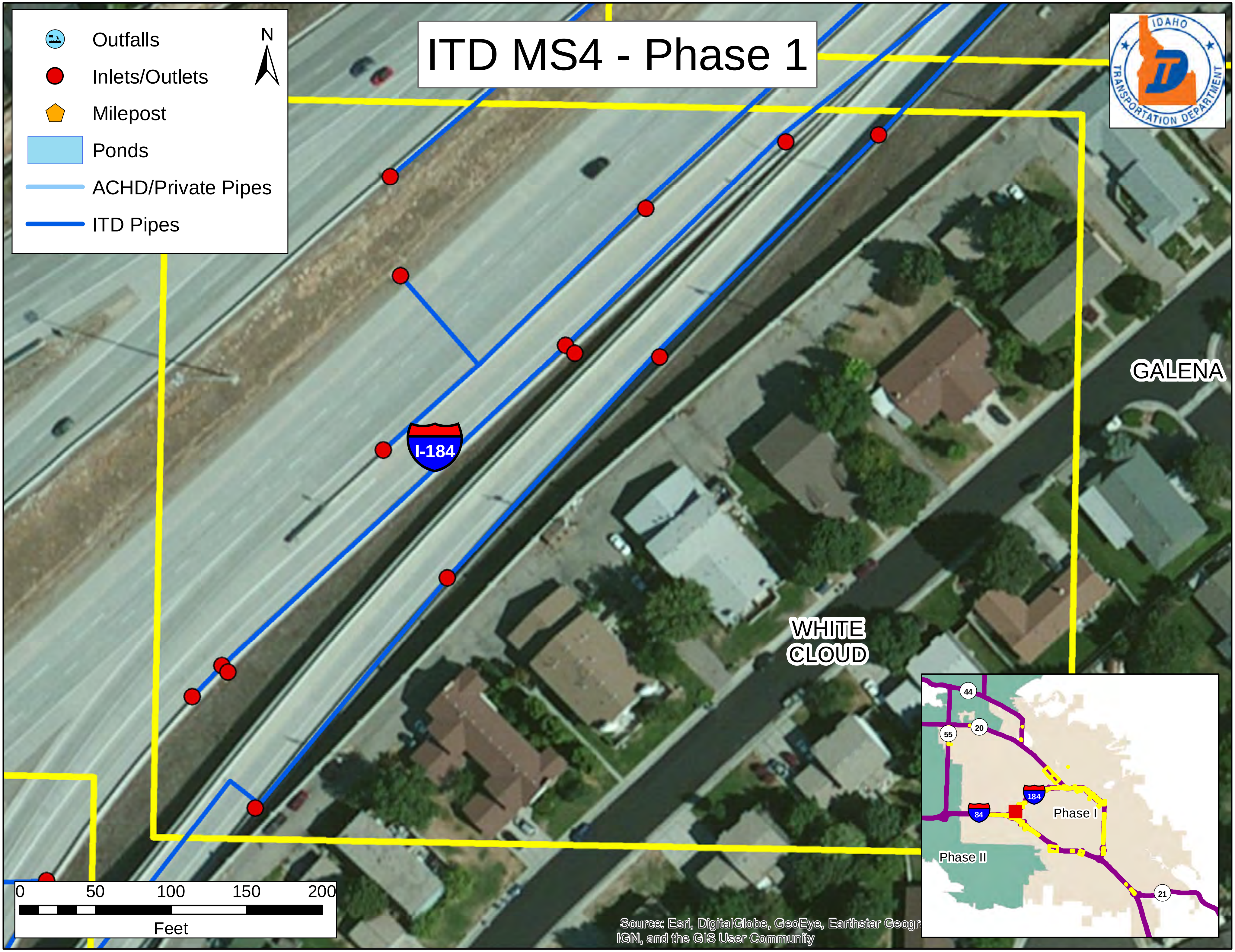


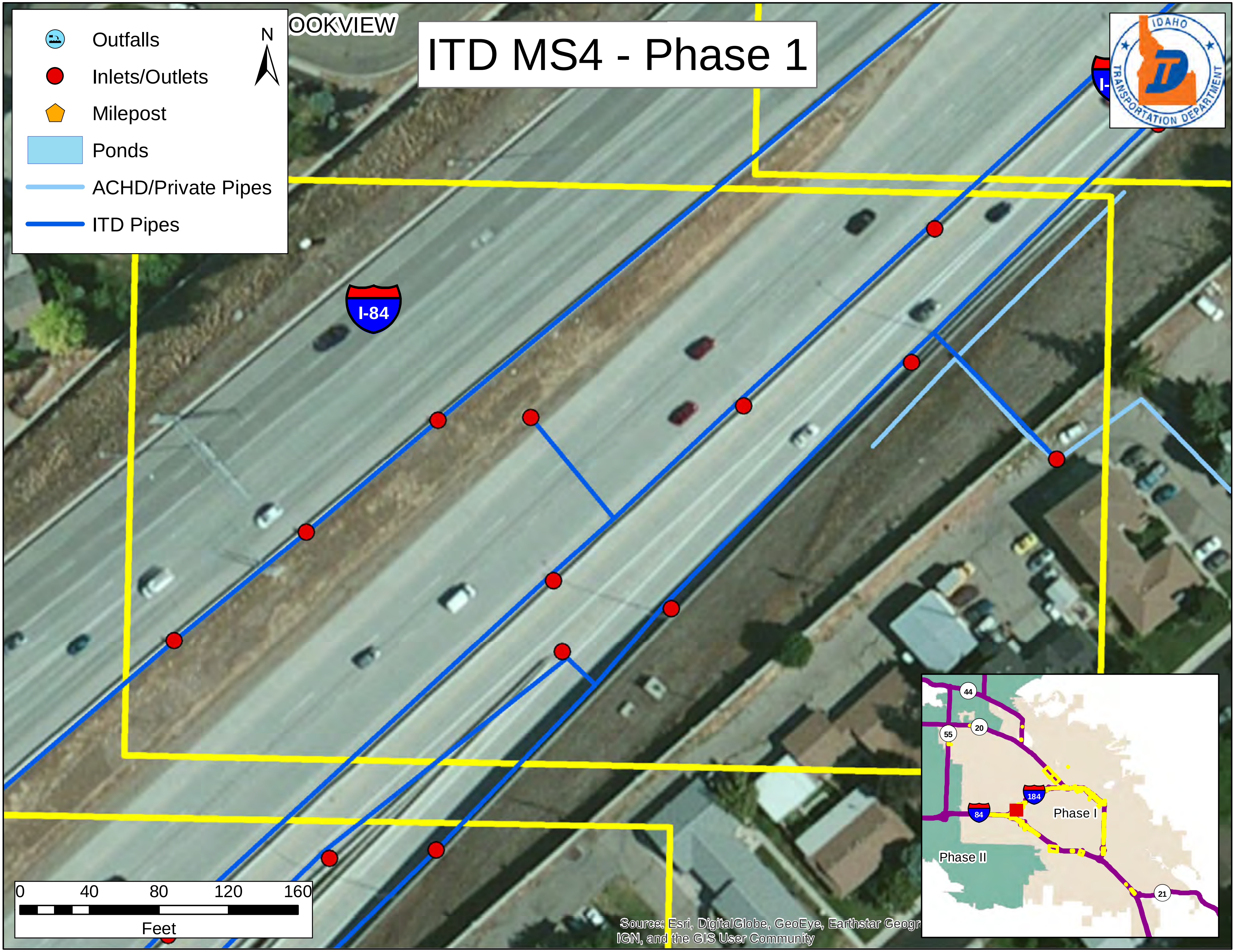
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-184
MCMULLEN
WHITE CLOUD
BOULDER
0 80 160 240 320
Feet
44
20
55
184
84
Phase I
Phase II
21
IGN, and the GIS User Community

Datum: NAD83



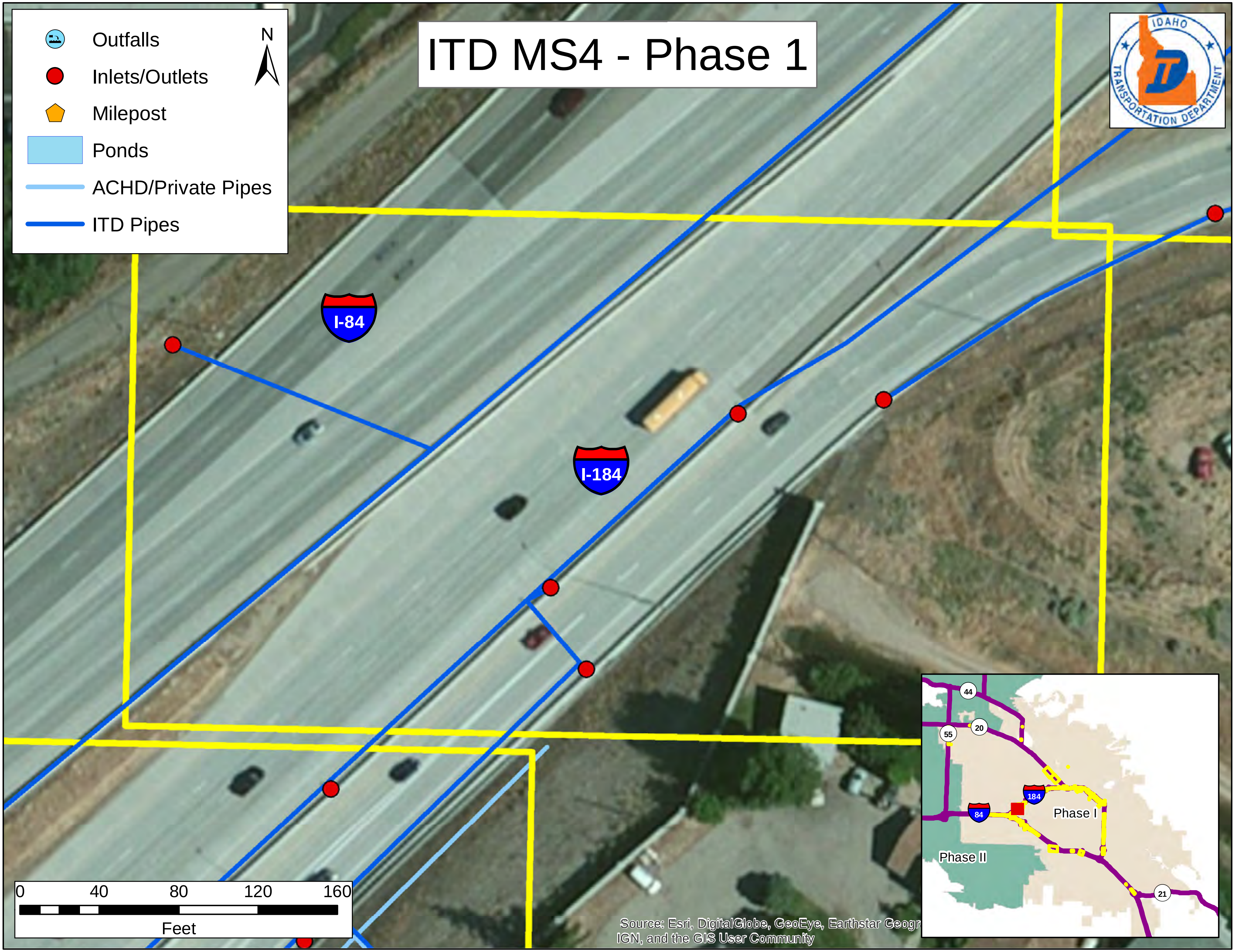
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
I-184
GALENA
WHITE CLOUD
IDAHO TRANSPORTATION DEPARTMENT
0 50 100 150 200
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
OOKVIEW
I-84
0
40
80
120
160
Feet
Phase I
Phase II
44
55
20
184
84
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

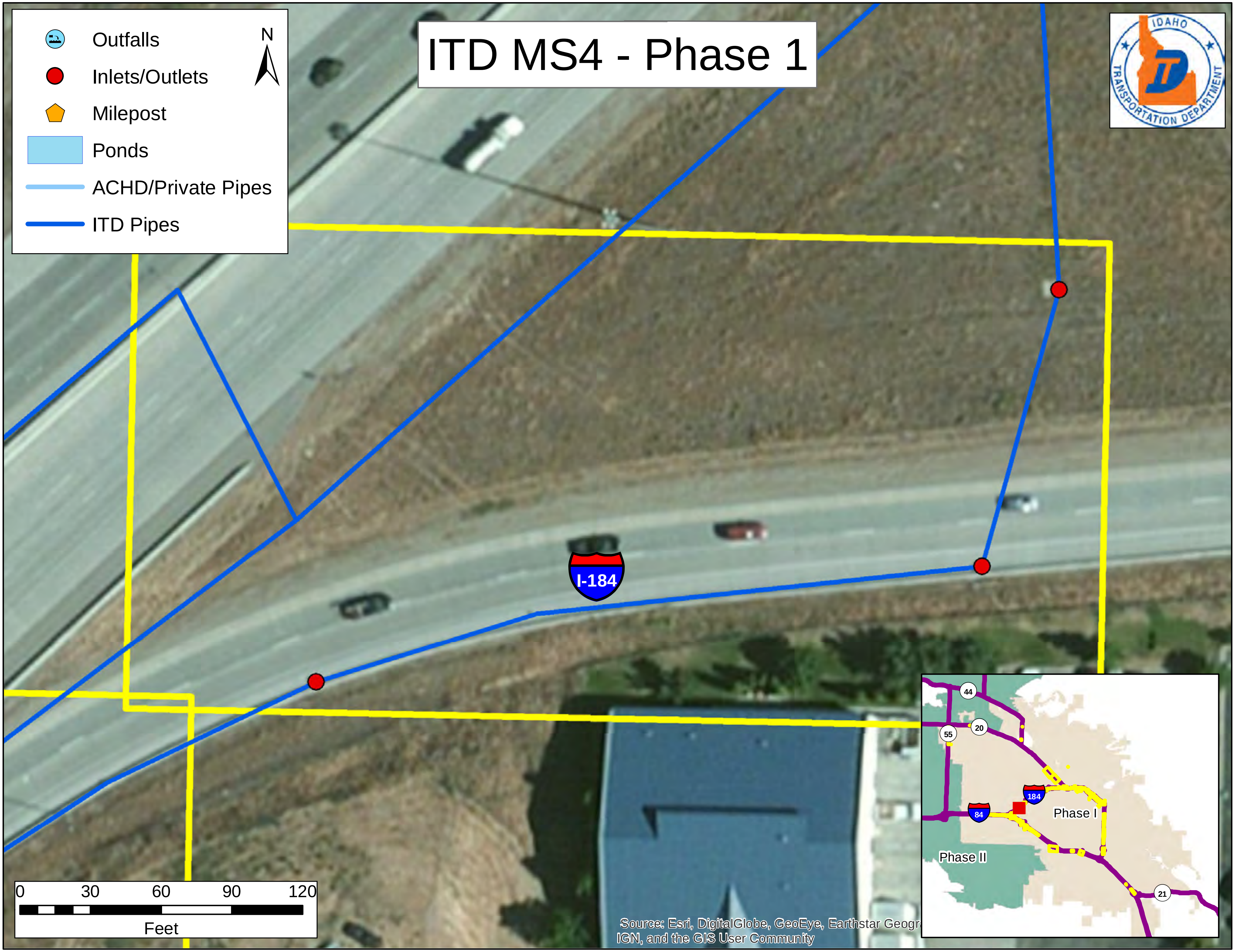
Datum: NAD83



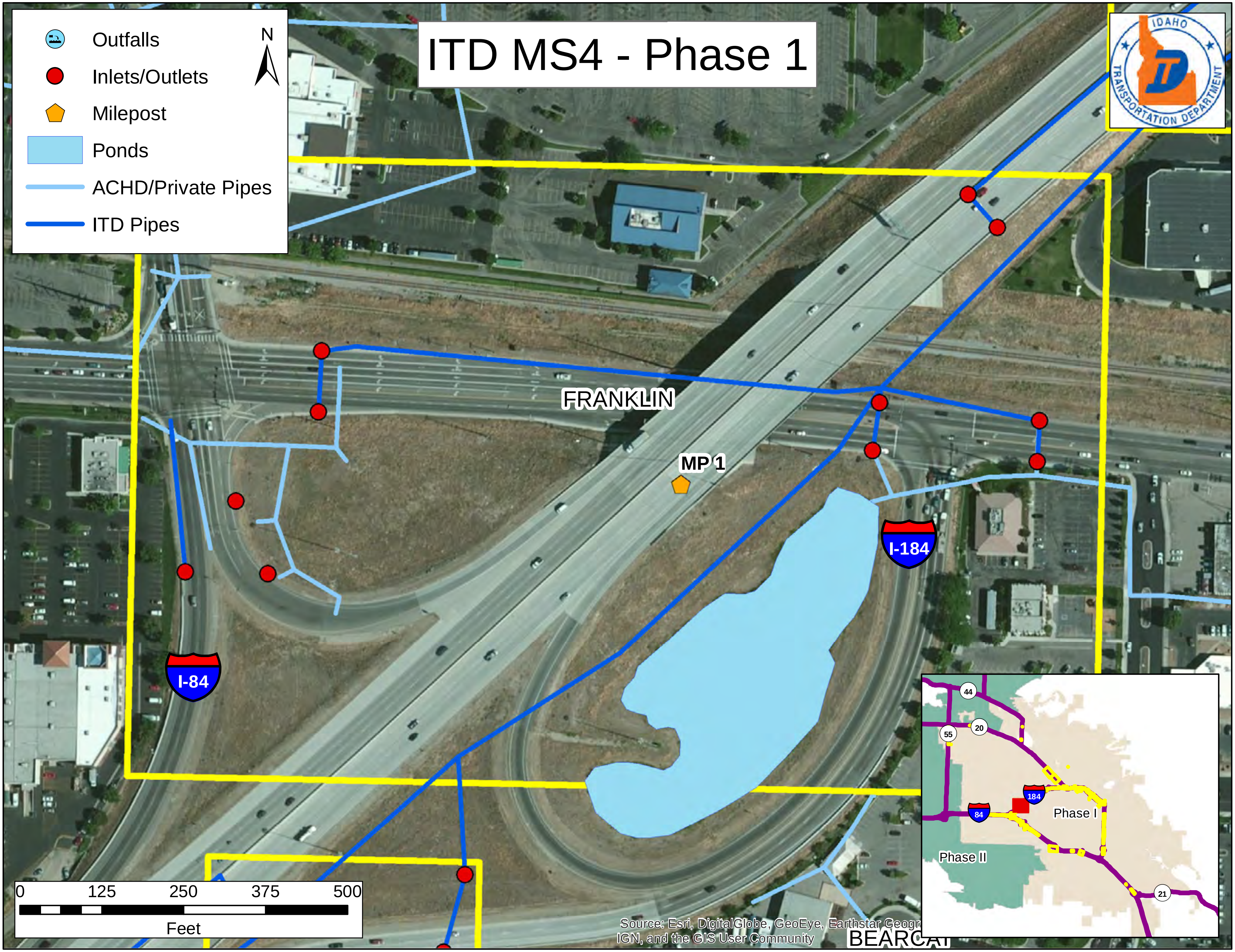
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-84
I-184
0
40
80
120
160
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83

ITD MS4 - Phase 1

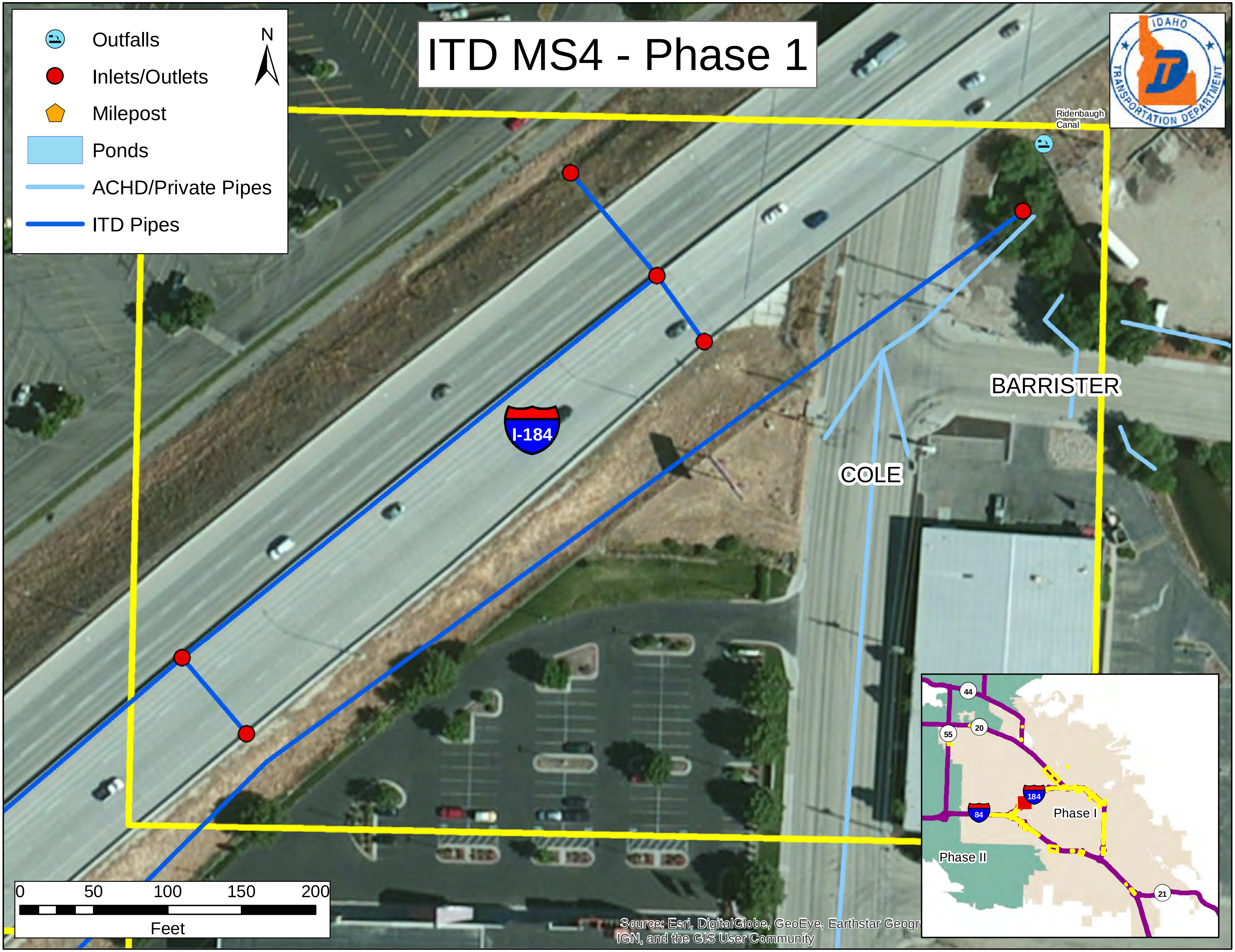


Datum: NAD83

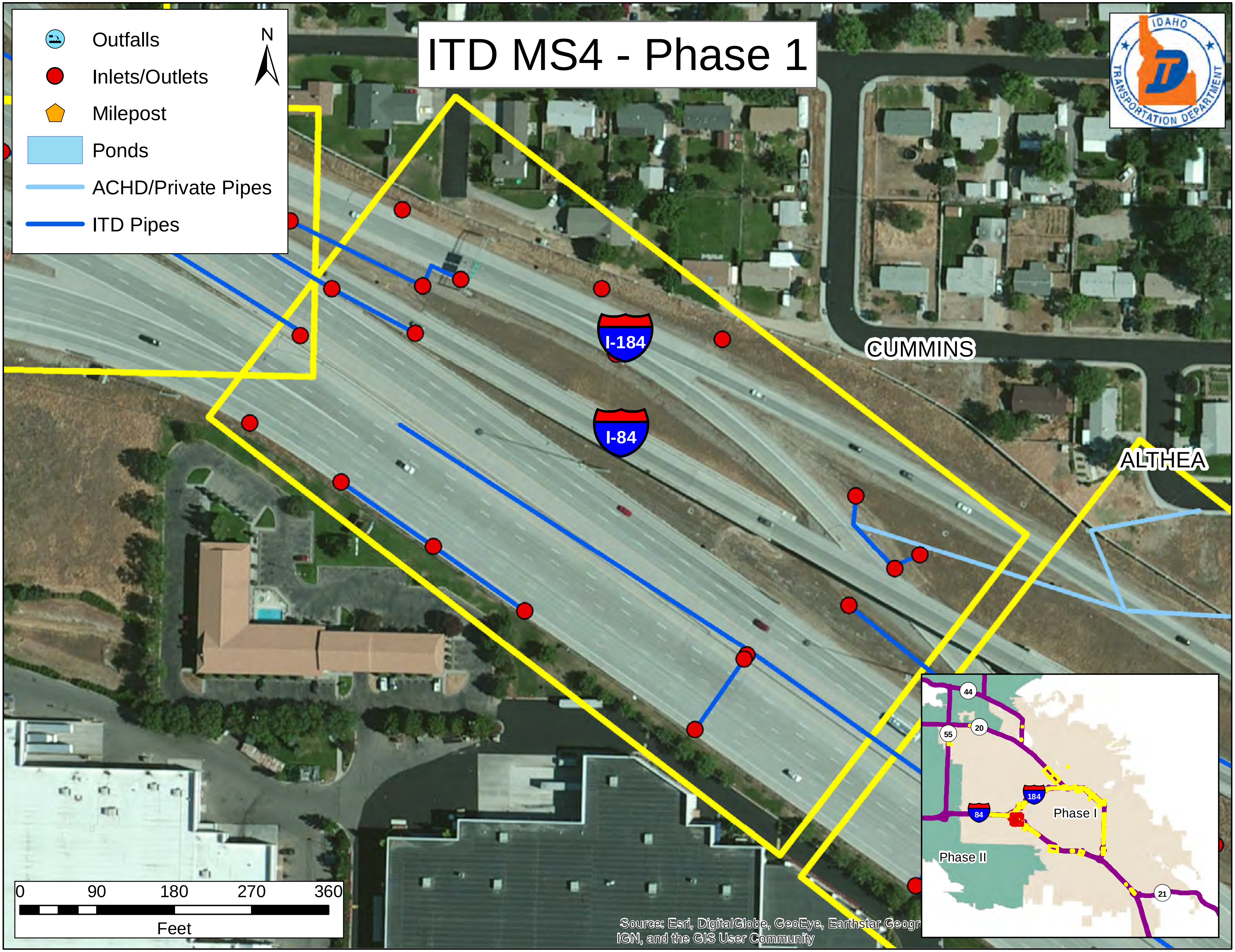


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
FRANKLIN
MP 1
I-184
I-84
0
125
250
375
500
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
BEARCAT
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
Ridenbaugh Canal
I-184
BARRISTER
COLE
0 50 100 150 200
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-184
I-84
CUMMINS
ALTHEA
0
90
180
270
360
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
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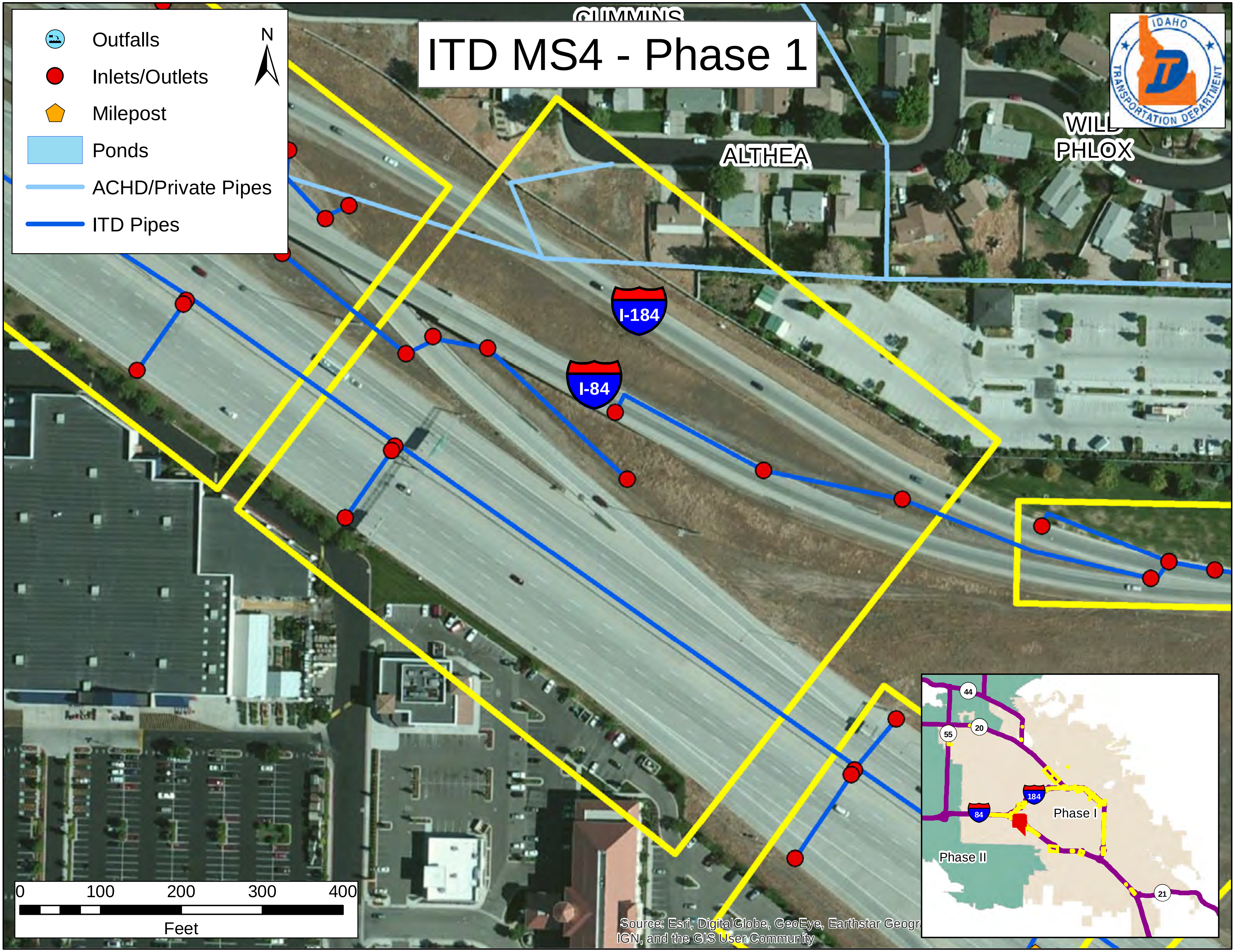
55
184
84
21
Phase I
Phase II
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
ALTHEA
WILD PHLOX
I-184
I-84
IDAHO TRANSPORTATION DEPARTMENT
0 100 200 300 400
Feet
Phase I
Phase II
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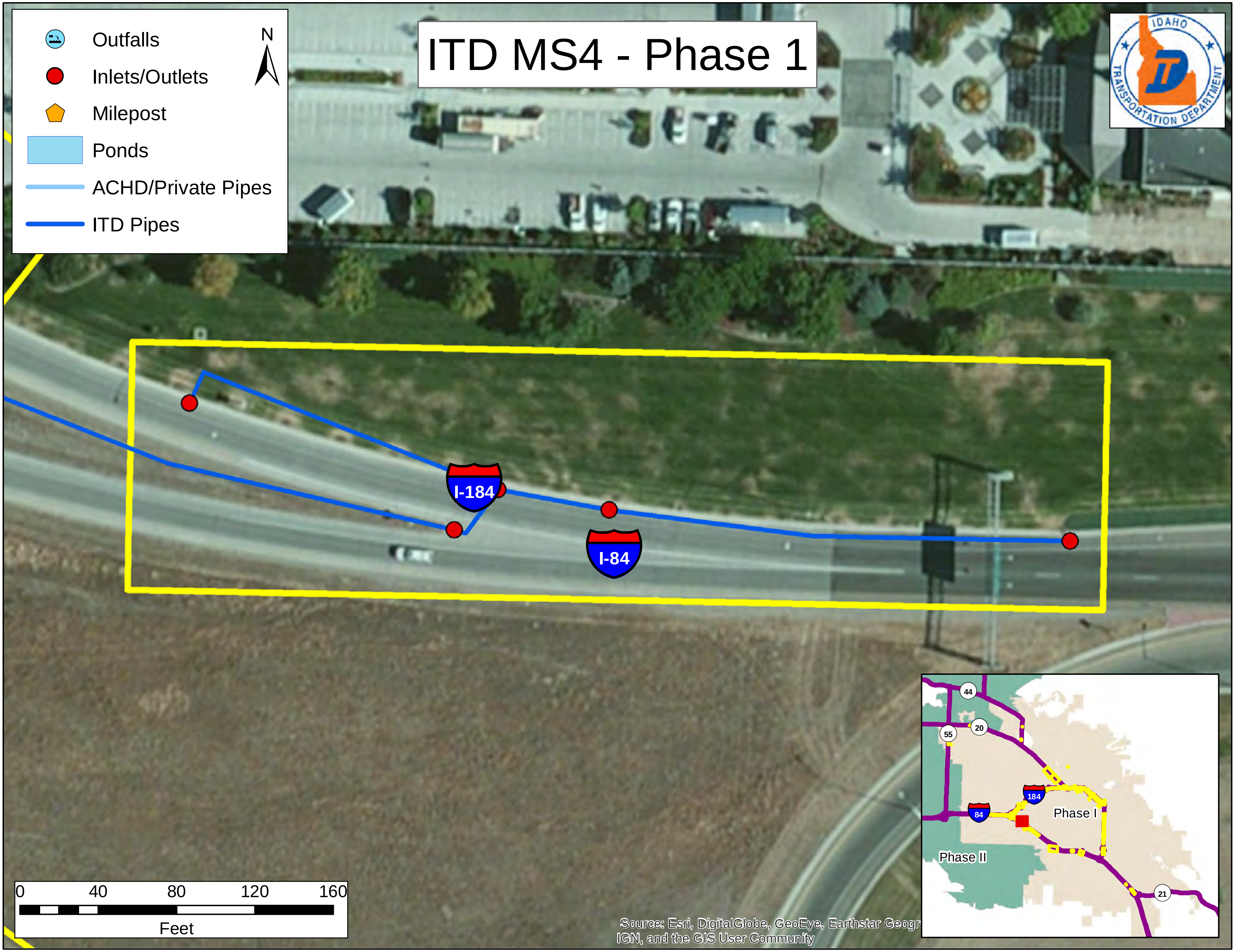
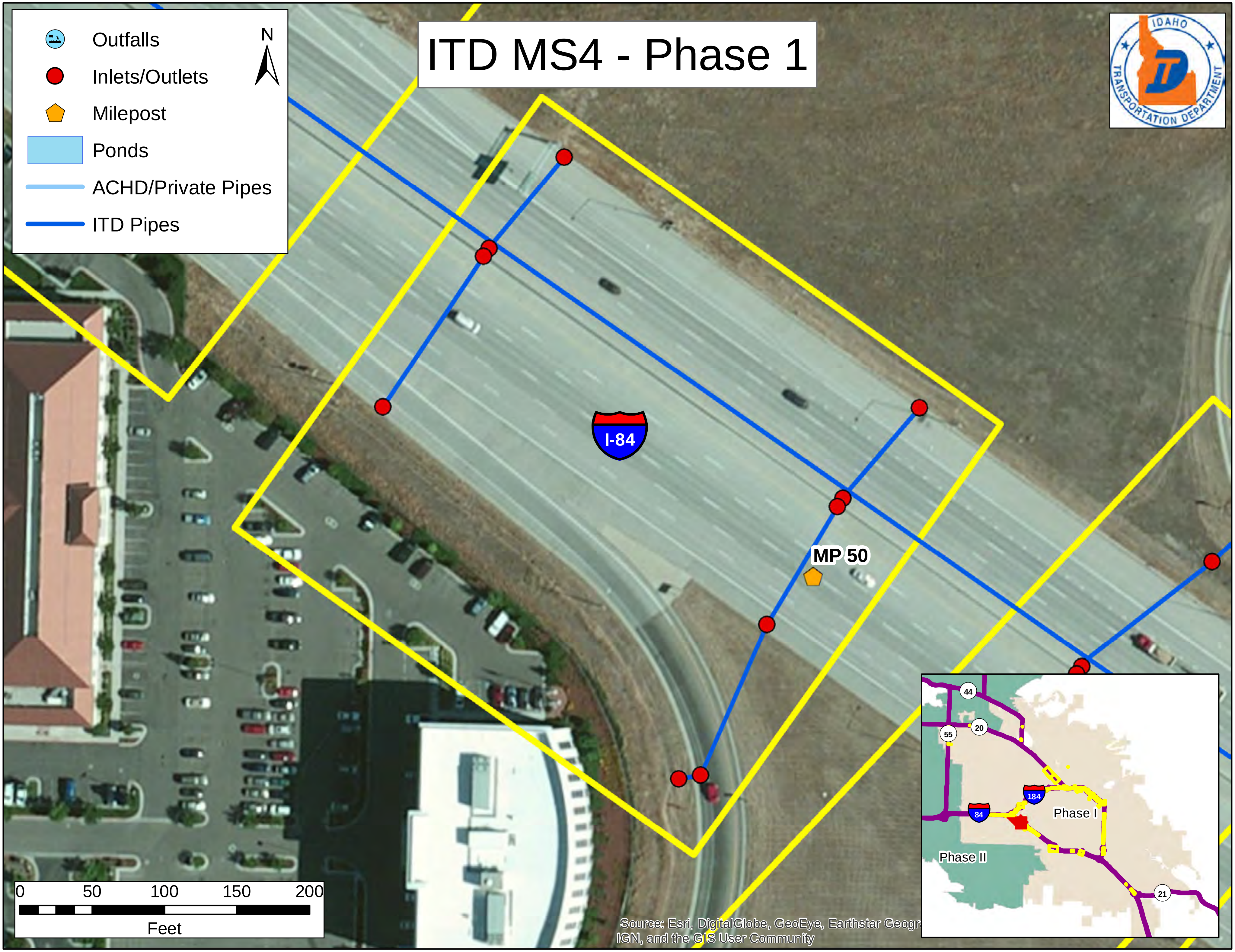
184
84
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

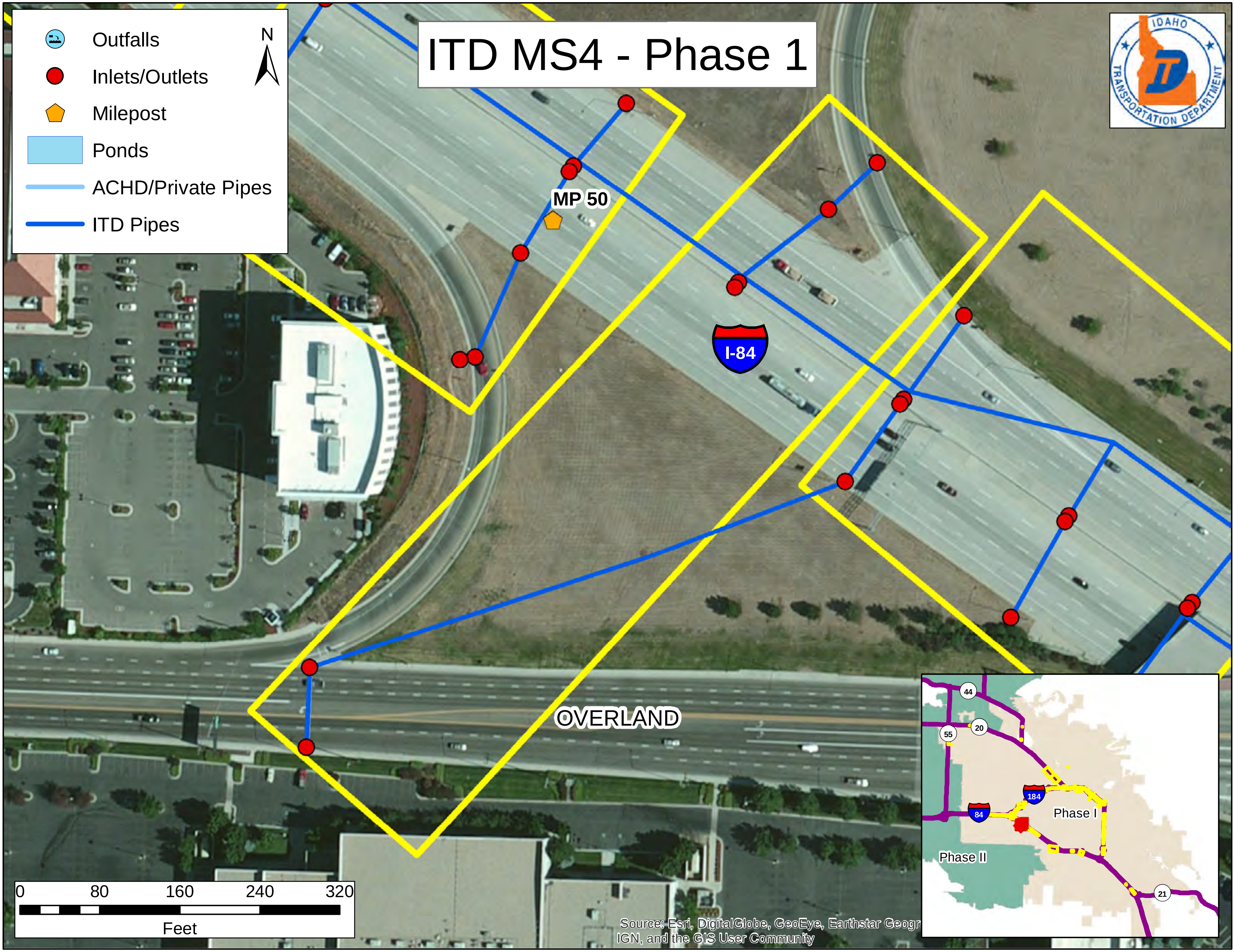
Datum: NAD83

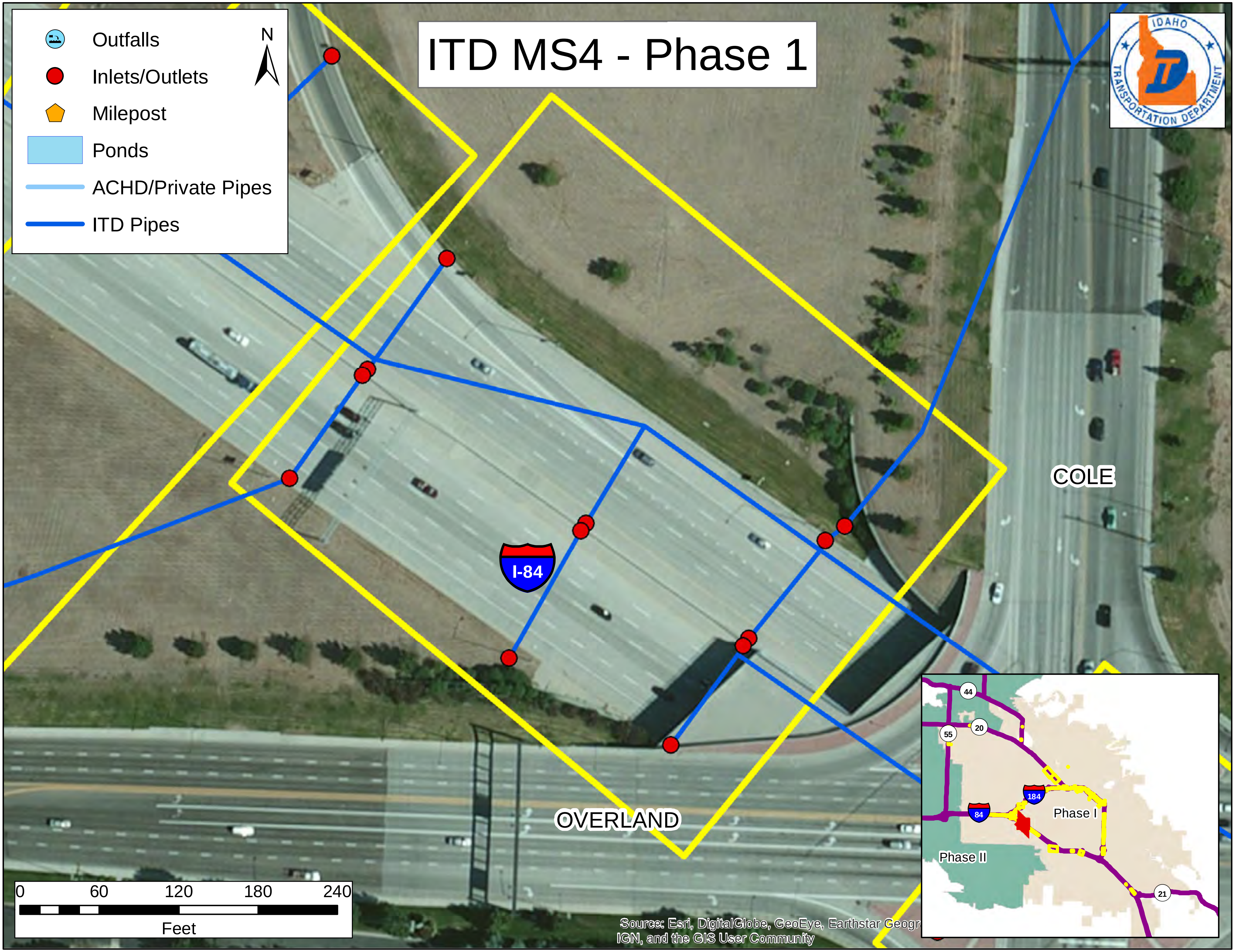

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-184
I-84
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
I-84
MP 50
0 50 100 150 200
Feet
Phase I
Phase II
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
IDAHO TRANSPORTATION DEPARTMENT

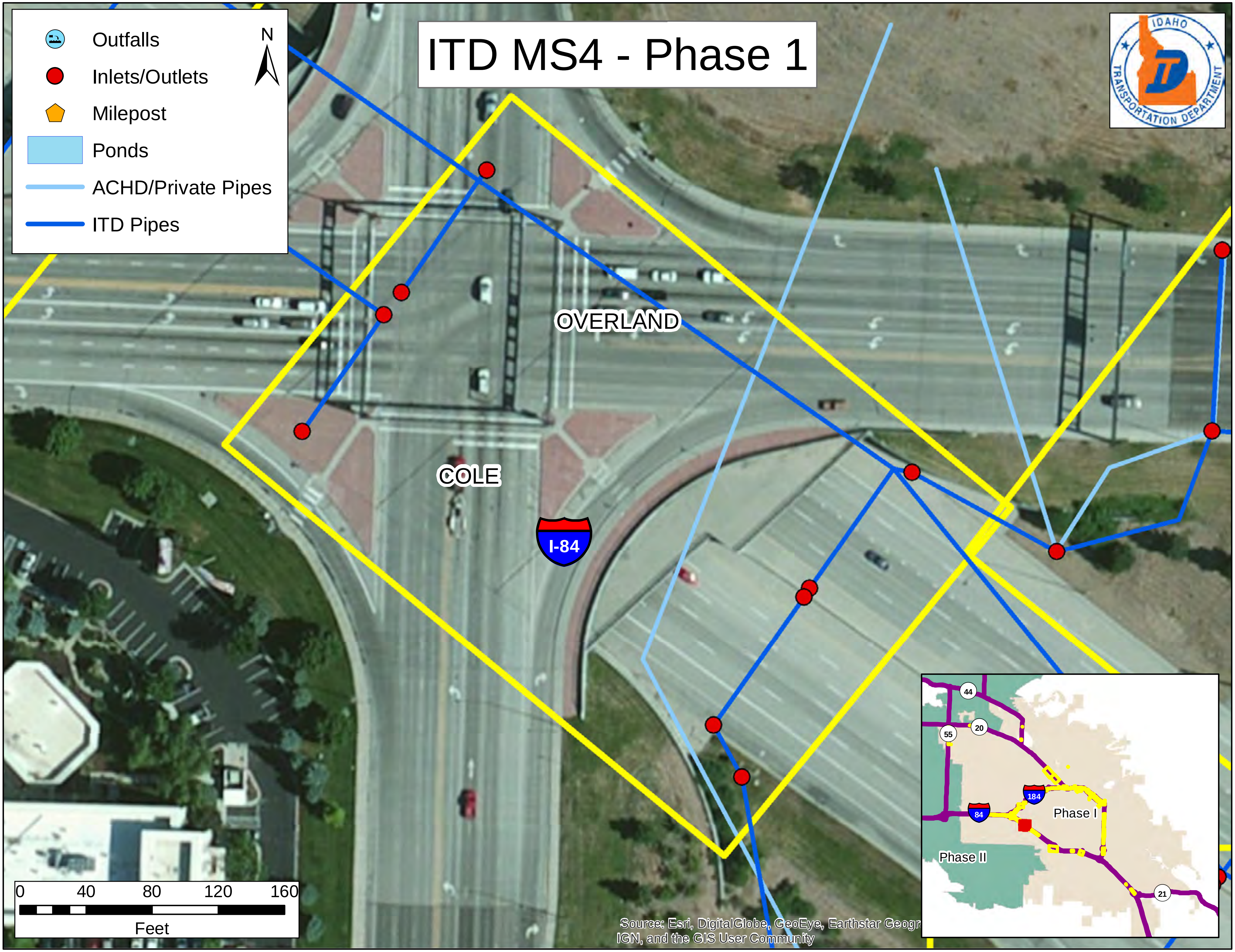
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
MP 50
I-84
OVERLAND
0
80
160
240
320
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT
Datum: NAD83

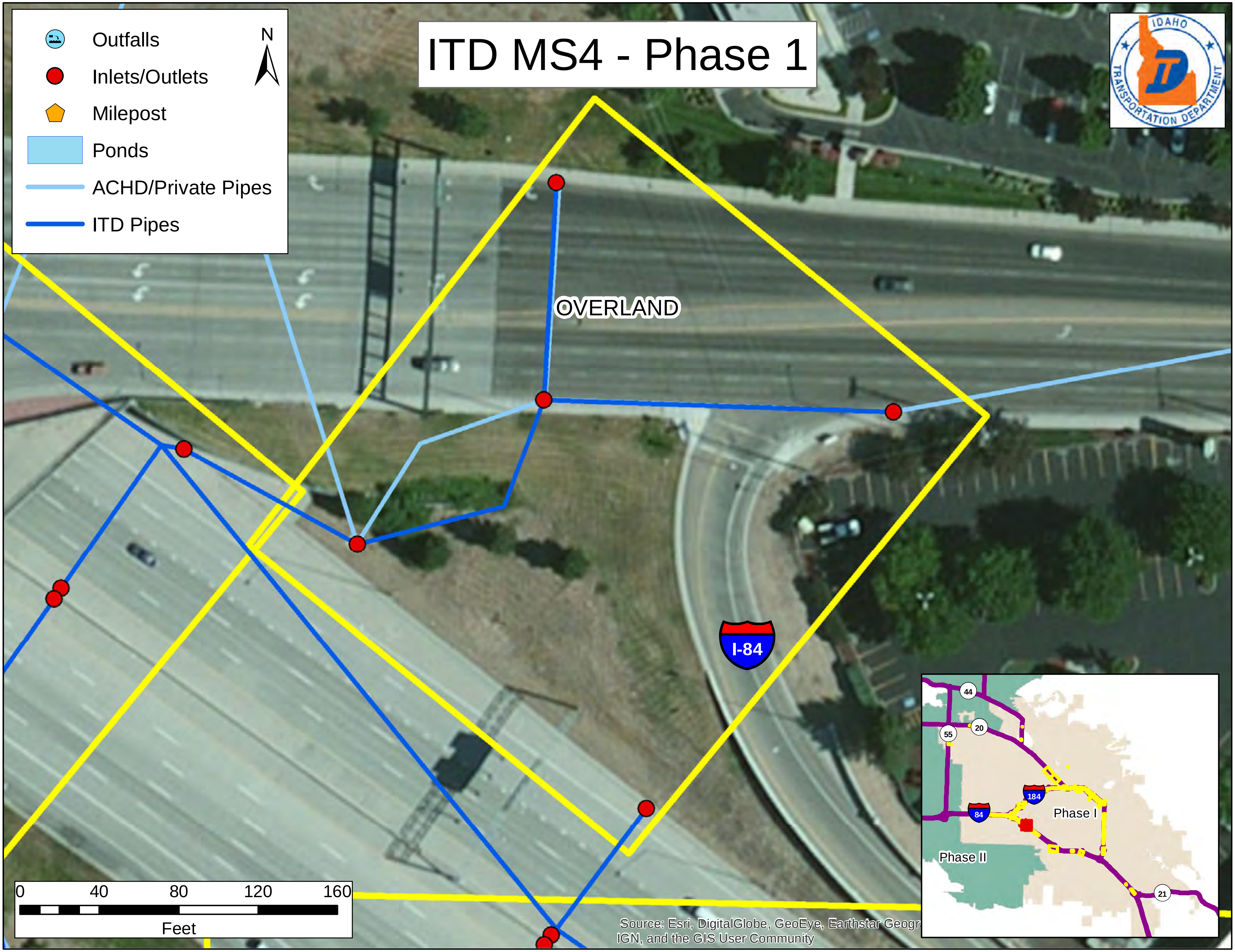


Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
ITD MS4 - Phase 1
IDAHO
TRANSPORTATION DEPARTMENT
I-84
COLE
OVERLAND
0
60
120
180
240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

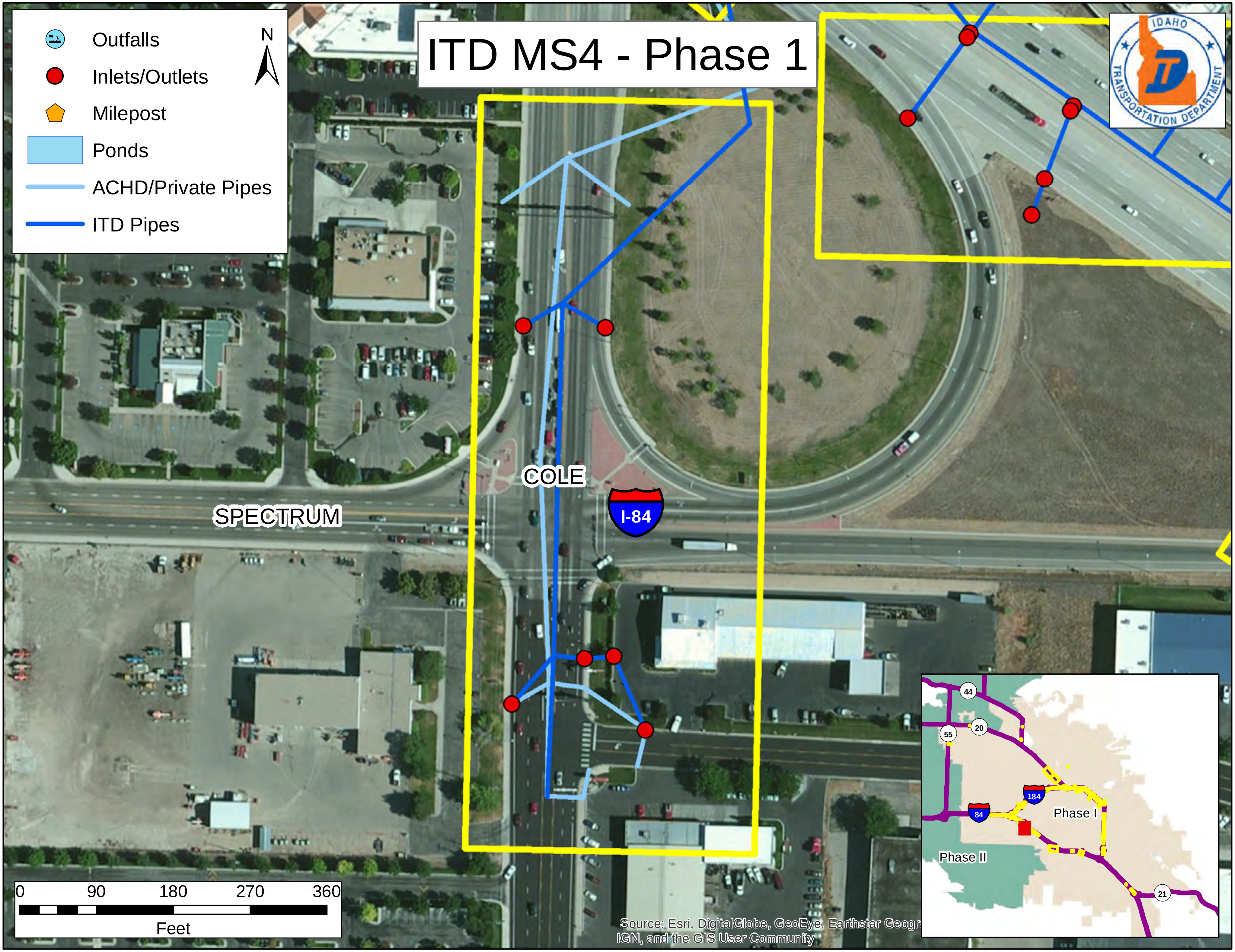
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
OVERLAND
COLE
I-84
0 40 80 120 160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

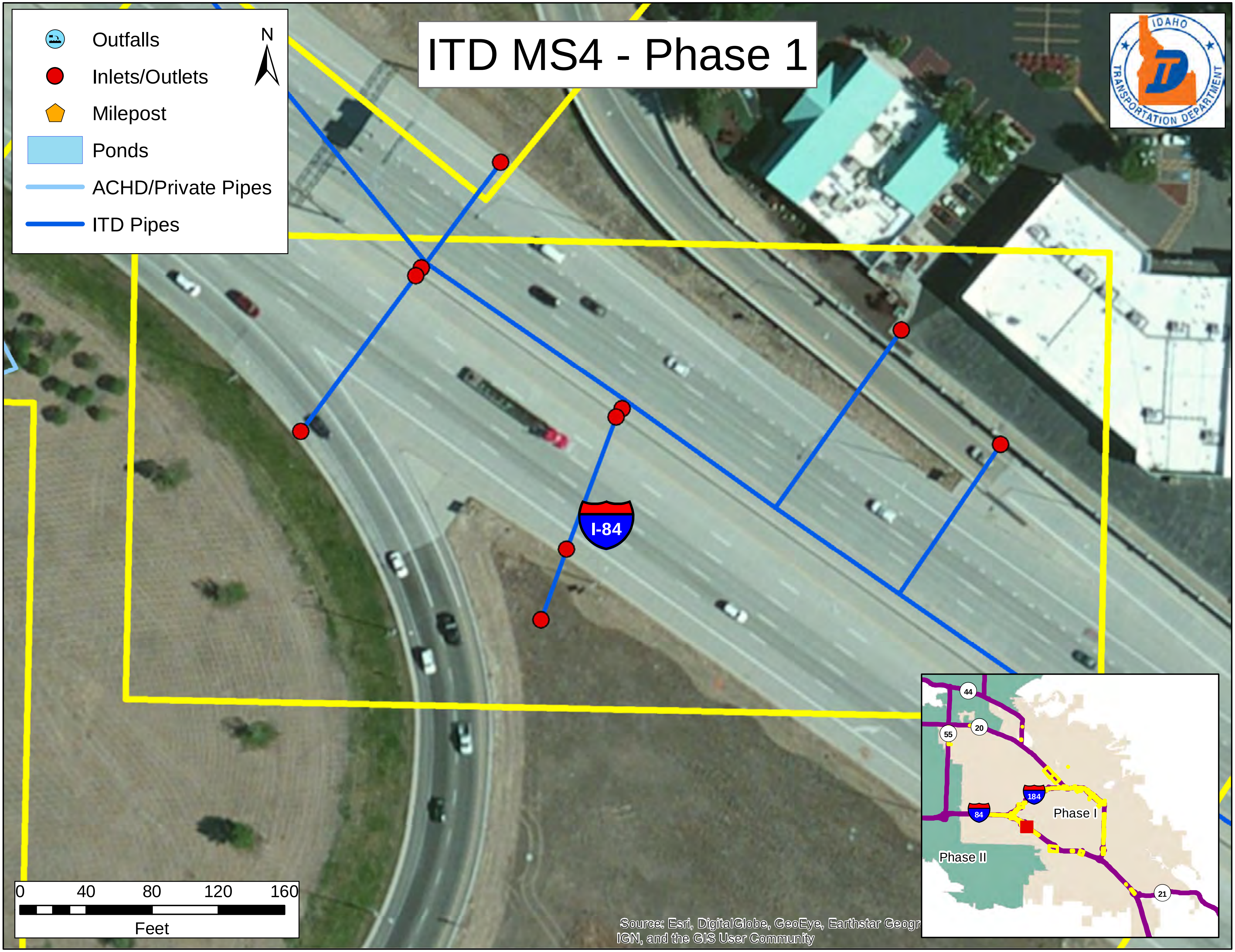

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
OVERLAND
I-84
0 40 80 120 160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
IDAHO TRANSPORTATION DEPARTMENT
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



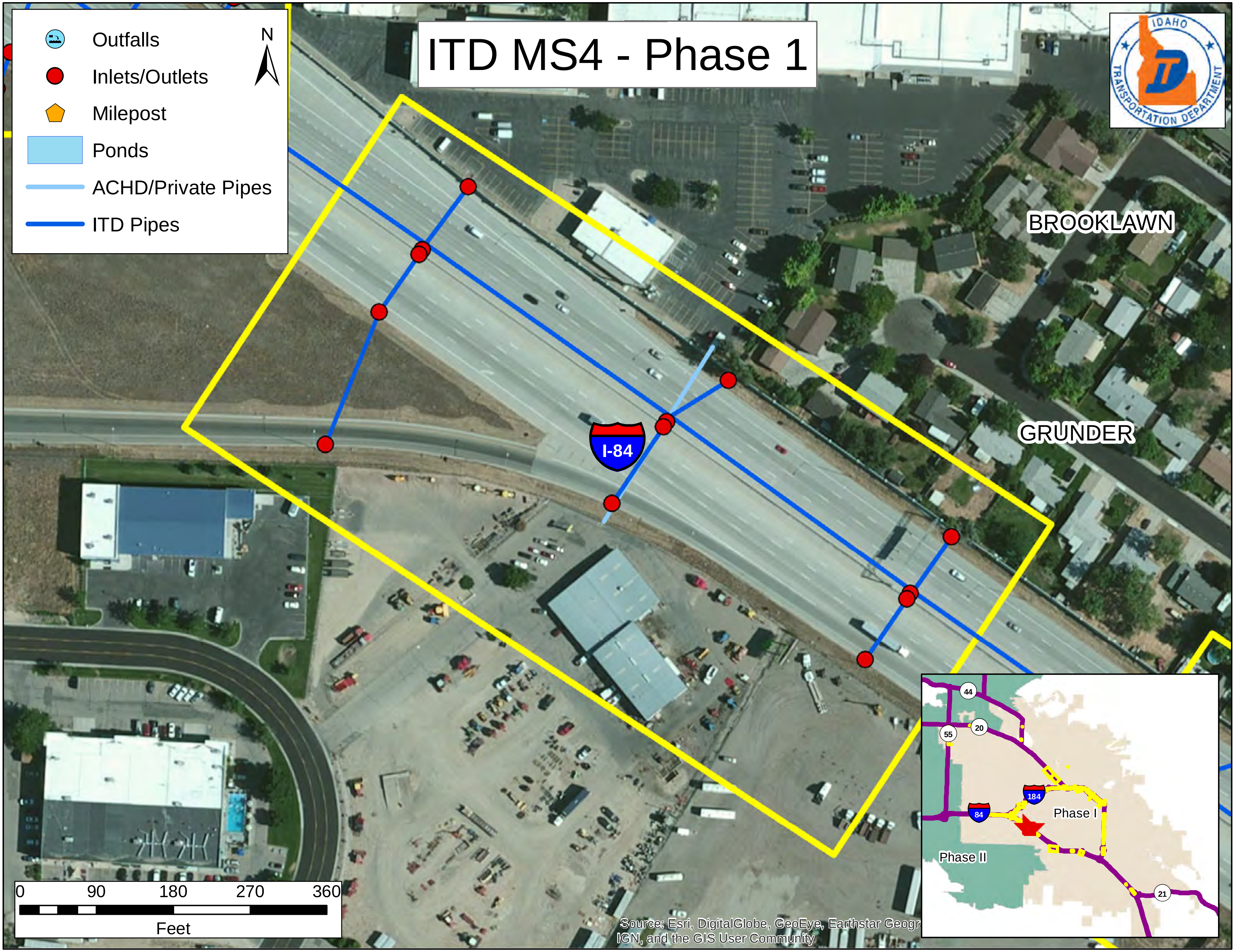
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
COLE
SPECTRUM
I-84
0
90
180
270
360
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



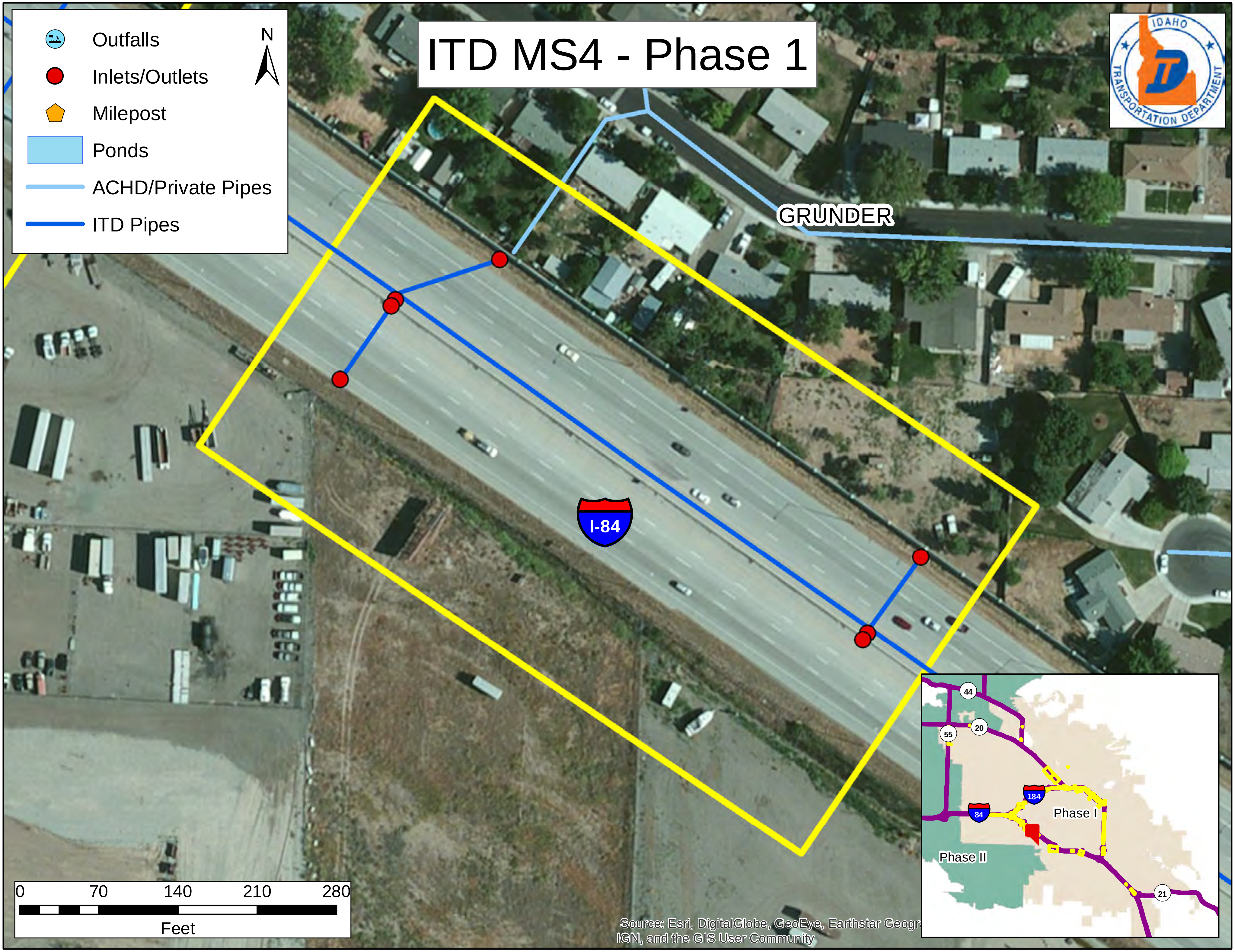
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-84
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

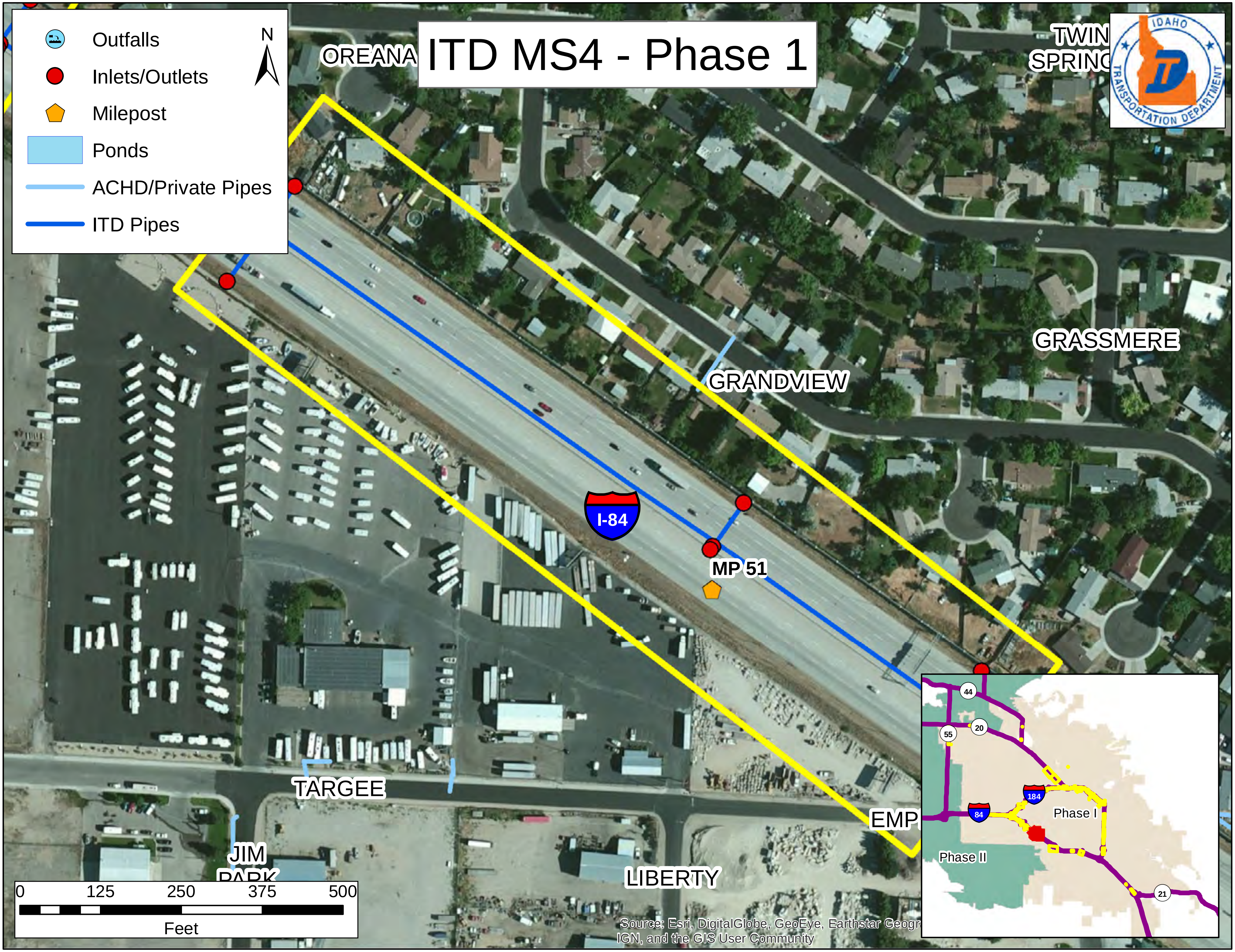


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
BROOKLAWN
GRUNDER
I-84
0
90
180
270
360
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT

Datum: NAD83

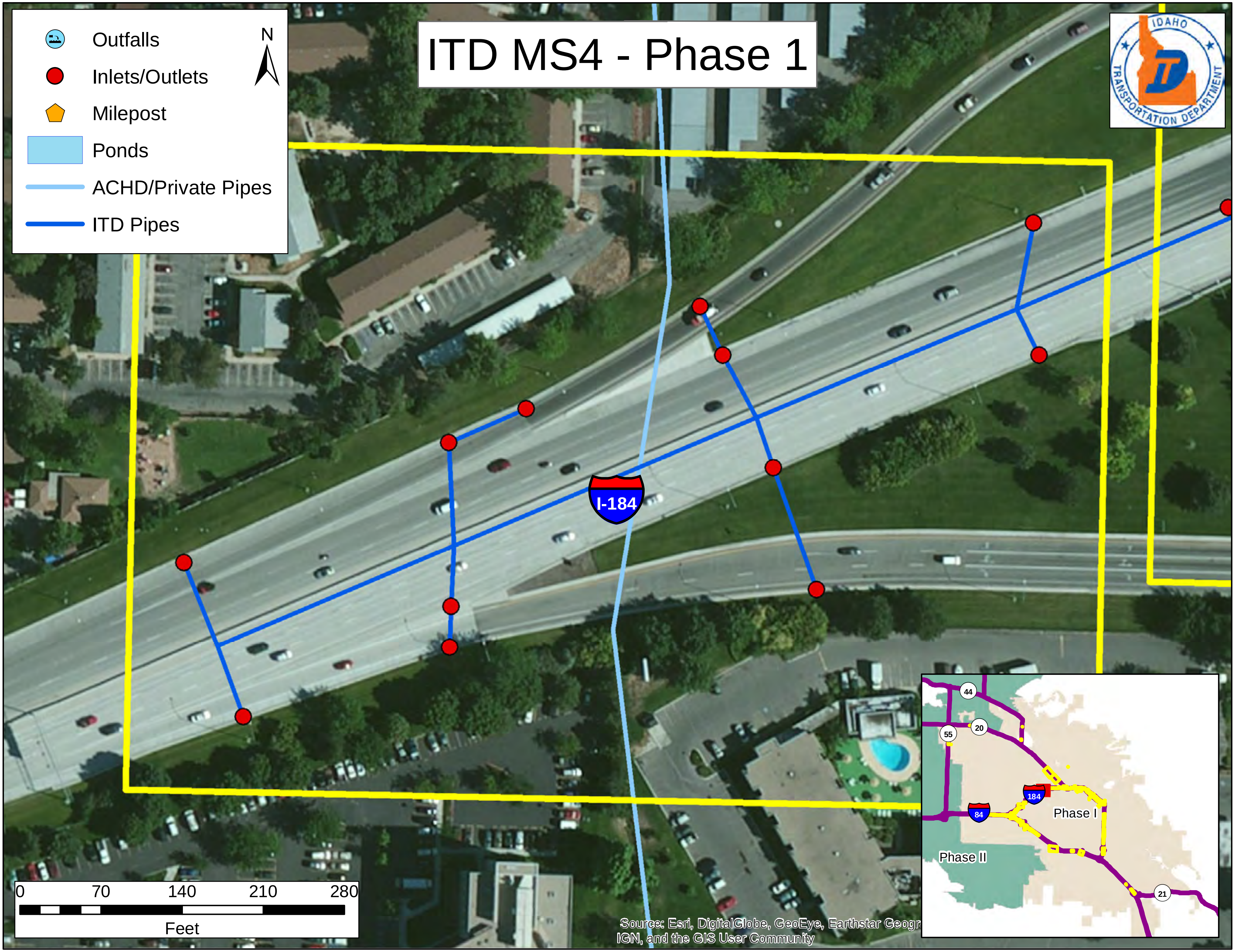

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
GRUNDER
I-84
IDAHO TRANSPORTATION DEPARTMENT
0 70 140 210 280
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
OREANA
TWIN SPRING
IDAHO TRANSPORTATION DEPARTMENT
GRASSMERE
GRANDVIEW
I-84
MP 51
TARGEE
JIM PARK
LIBERTY
EMP
0 125 250 375 500
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

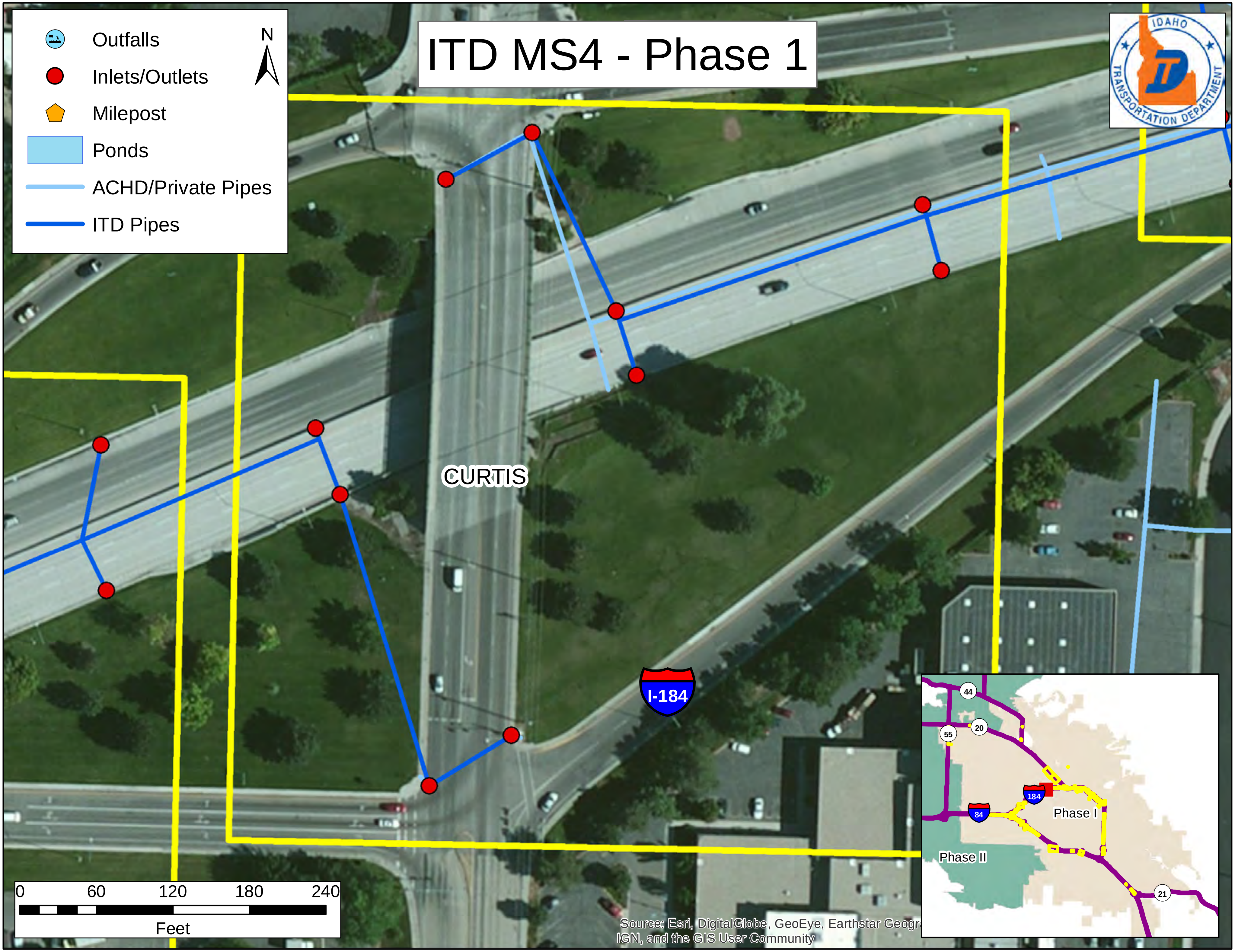

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
HARTMAN
IRVING
ALLUMBAUGH
CASCADE
GOSSETT
MP 2
I-184
NORWOOD
EMERALD
LIBERTY
DENTON ALLEY
RAYMOND
RAYMOND
0 230 460 690 920
Feet
Phase I
Phase II
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
I-184
0
70
140
210
280
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83

ITD MS4 - Phase 1



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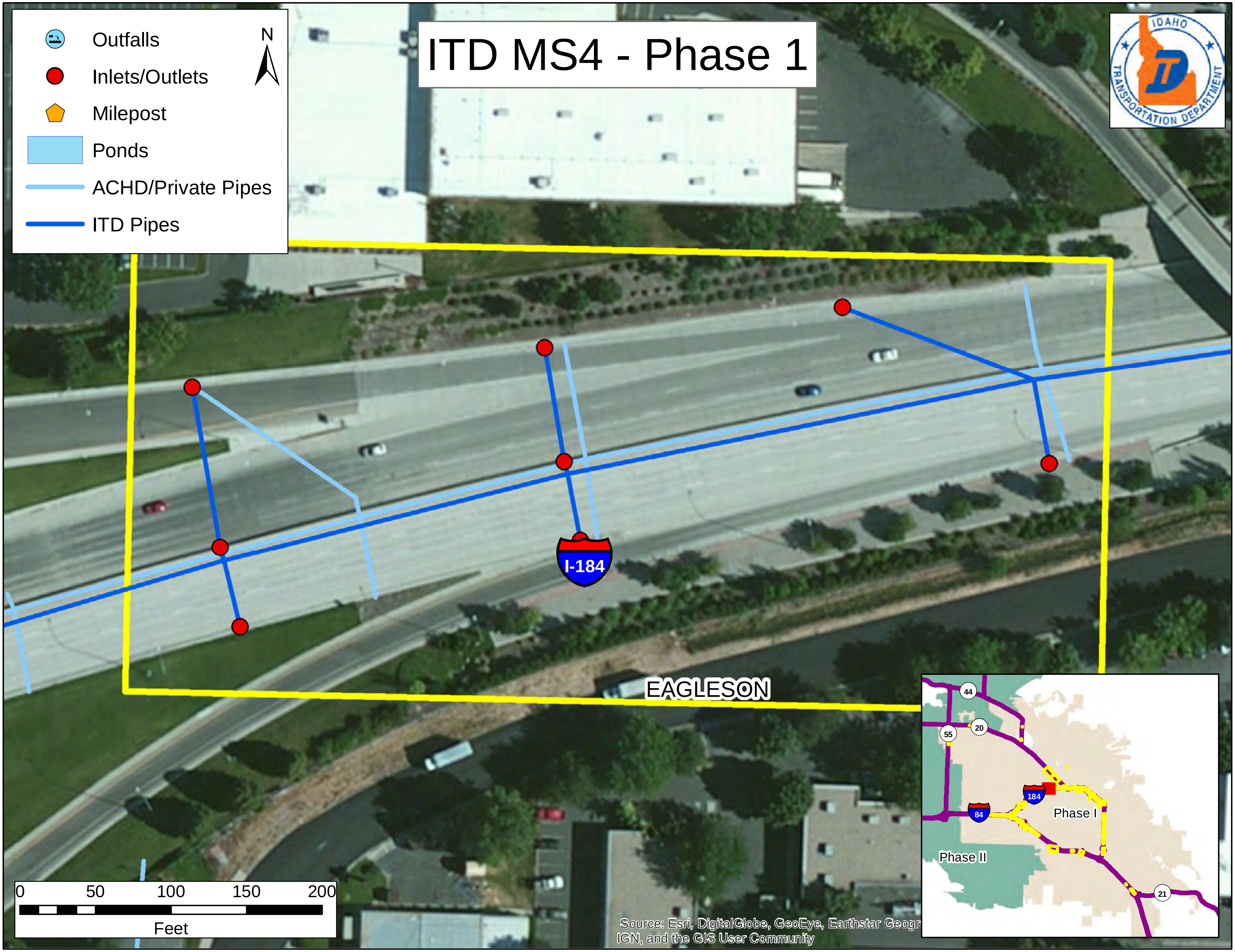
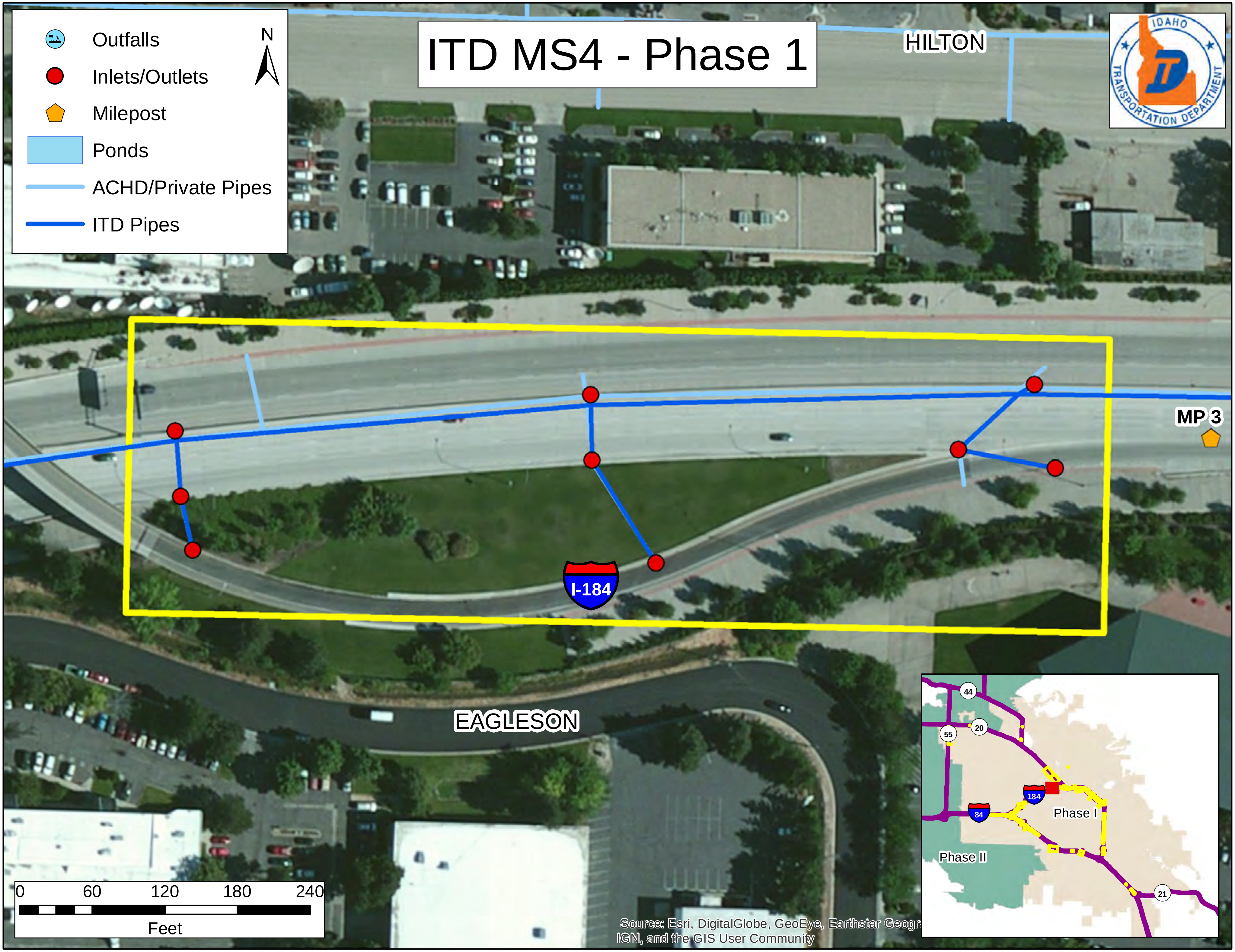
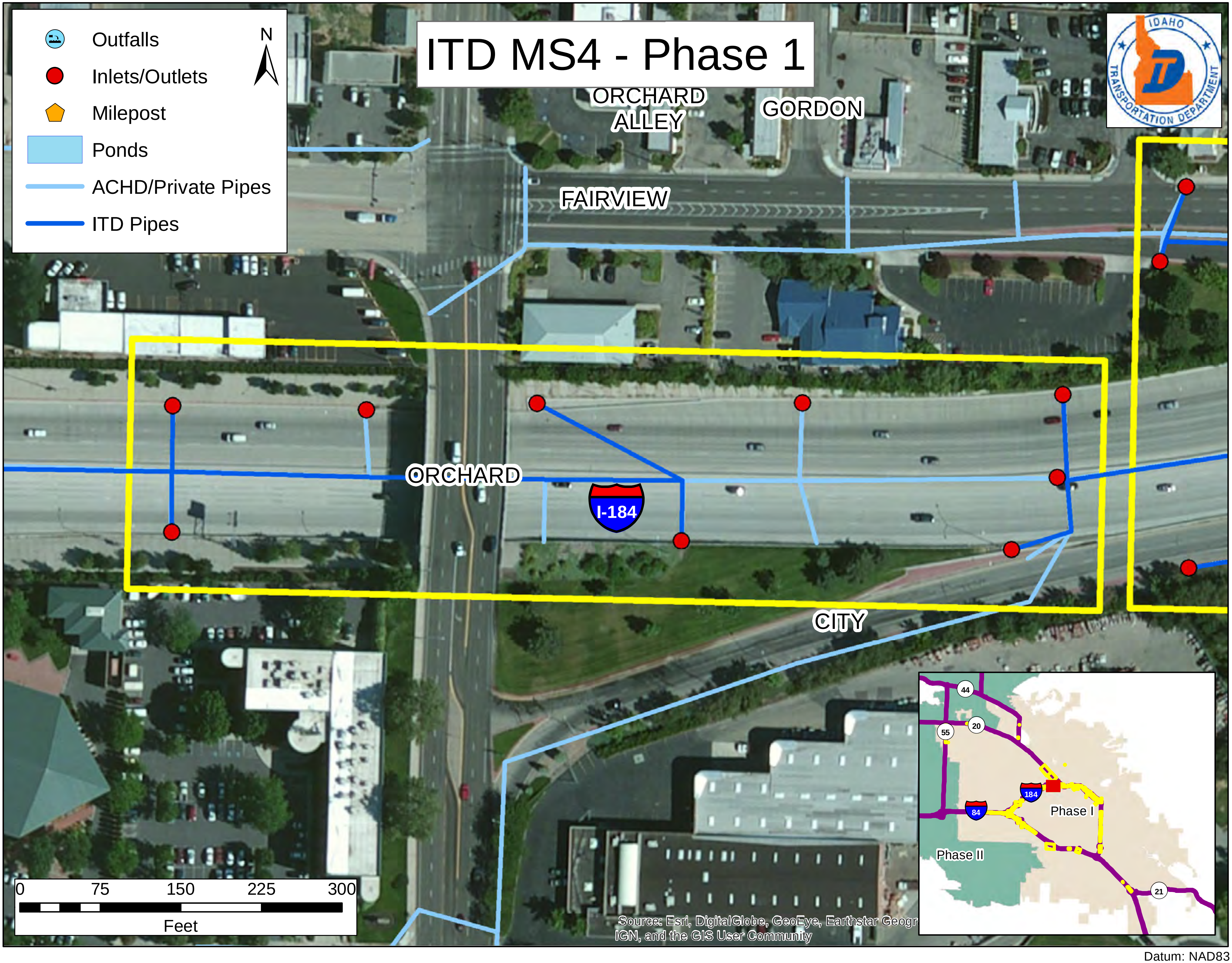
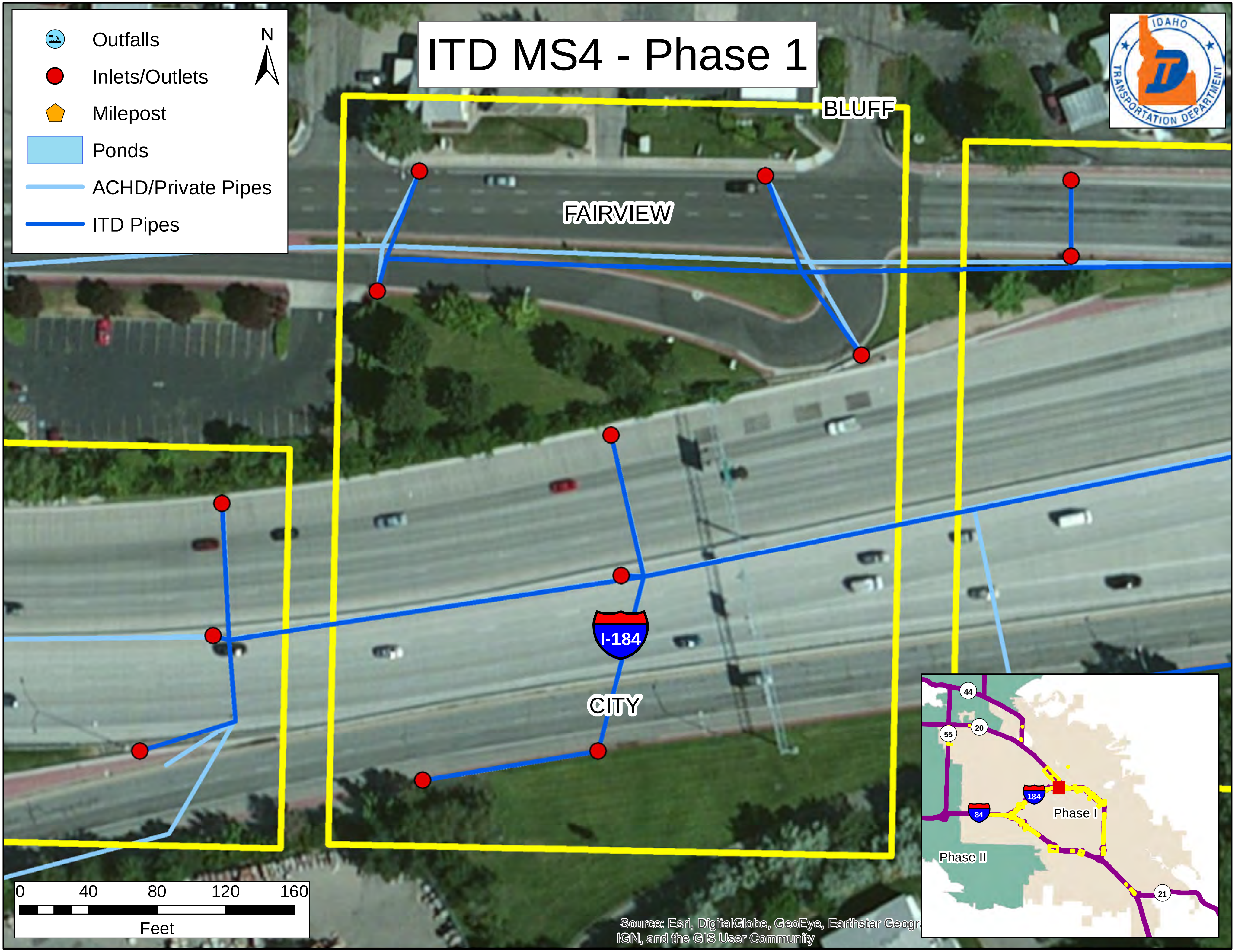

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
I-184
EAGLESON
0
50
100
150
200
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83

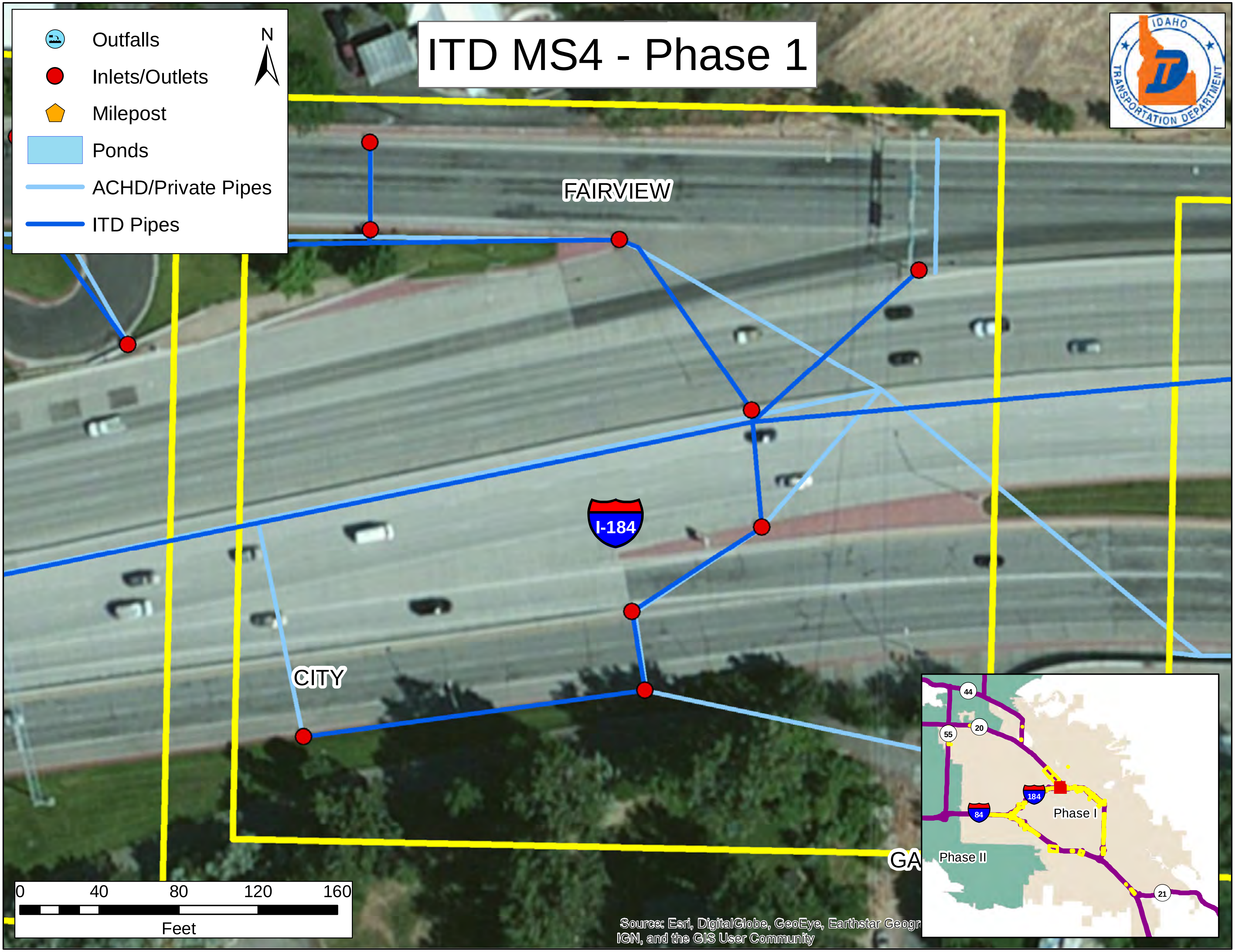

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
HILTON
MP 3
I-184
EAGLESON
0
60
120
180
240
Feet
Phase I
Phase II
184
84
44
20
55
21
IDAHO
TRANSPORTATION DEPARTMENT
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
ORCHARD ALLEY
GORDON
FAIRVIEW
ORCHARD
I-184
CITY
0 75 150 225 300
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
Datum: NAD83



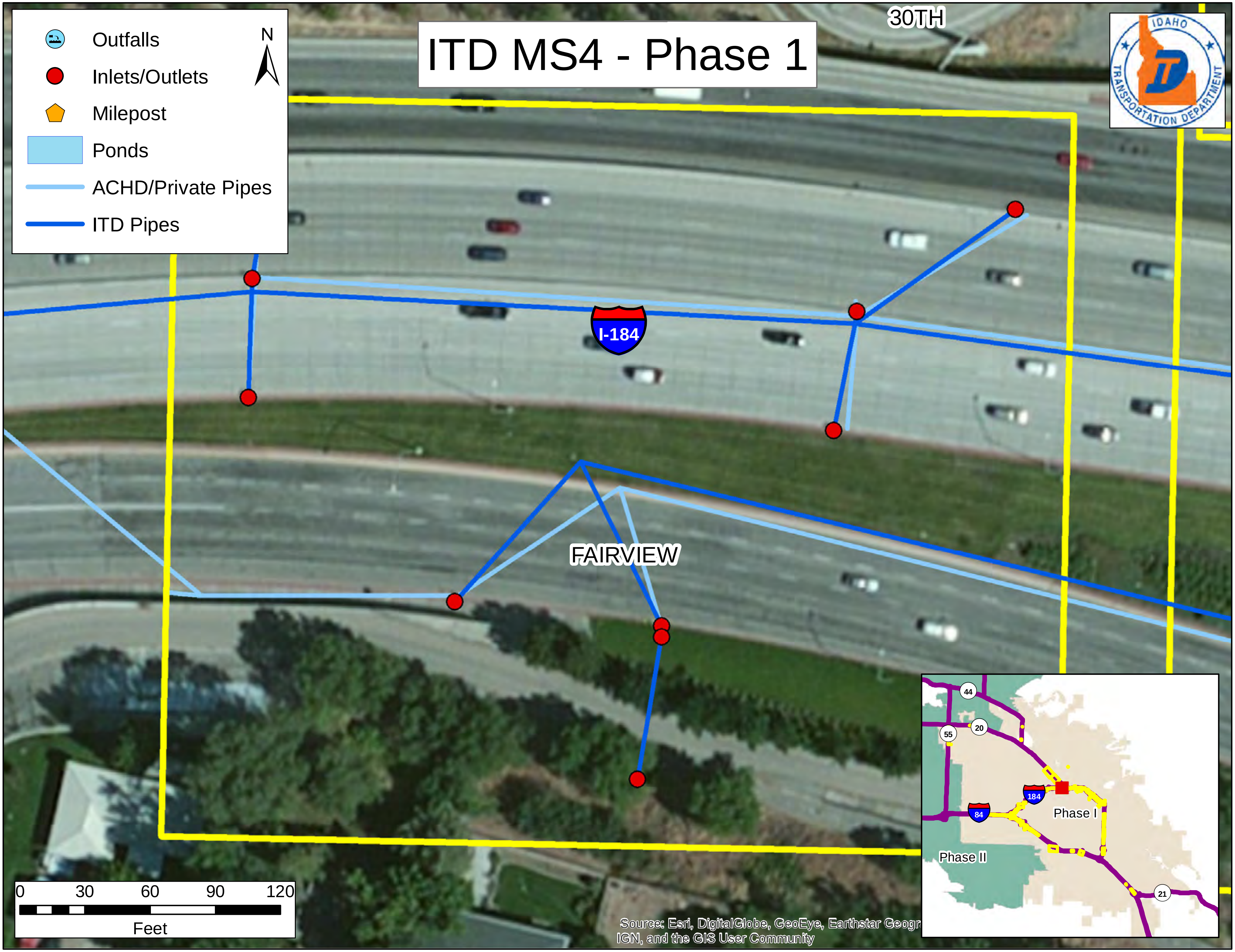
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
BLUFF
FAIRVIEW
I-184
CITY
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
FAIRVIEW
I-184
CITY
GA
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT

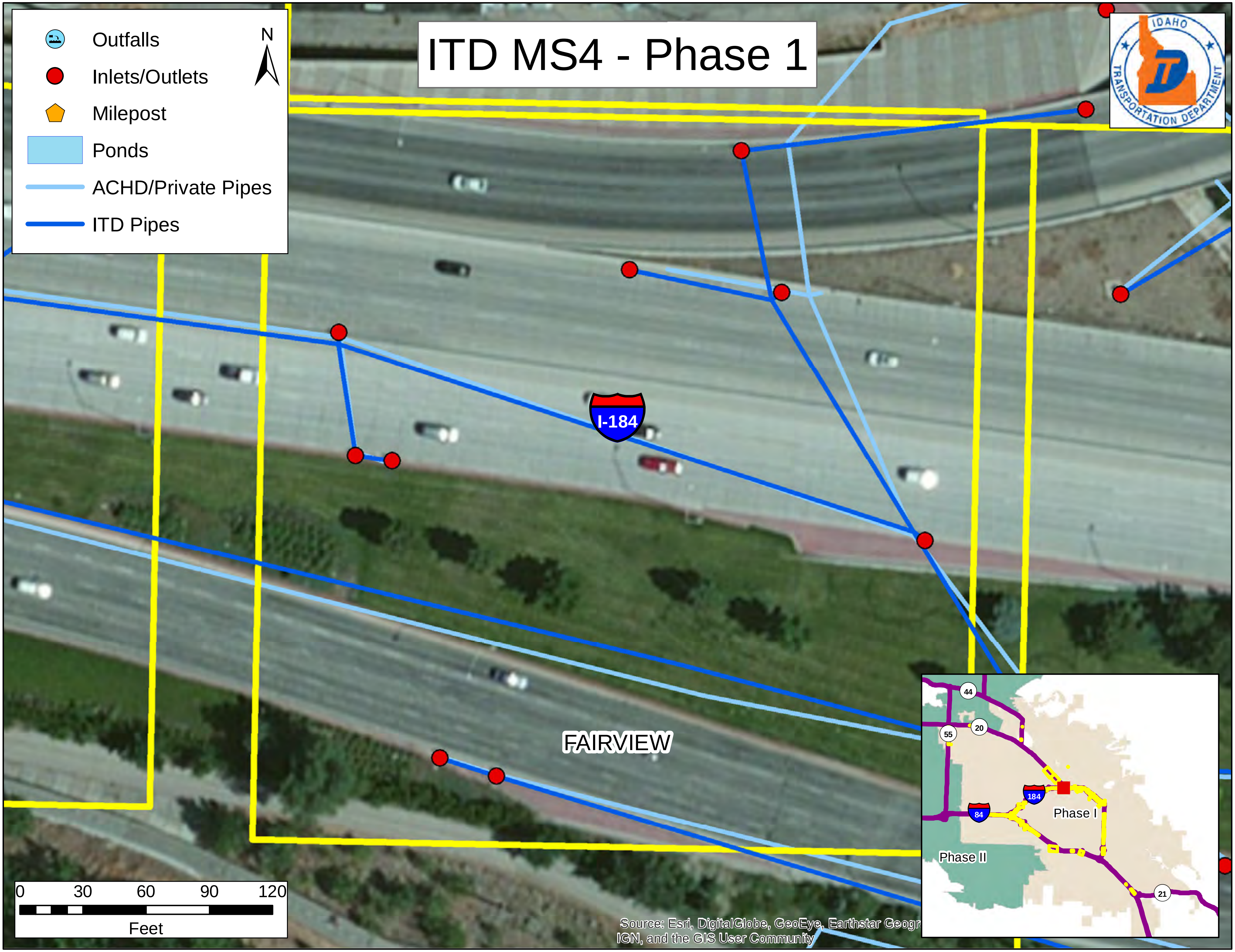
Datum: NAD83

ITD MS4 - Phase 1



Datum: NAD83

ITD MS4 - Phase 1



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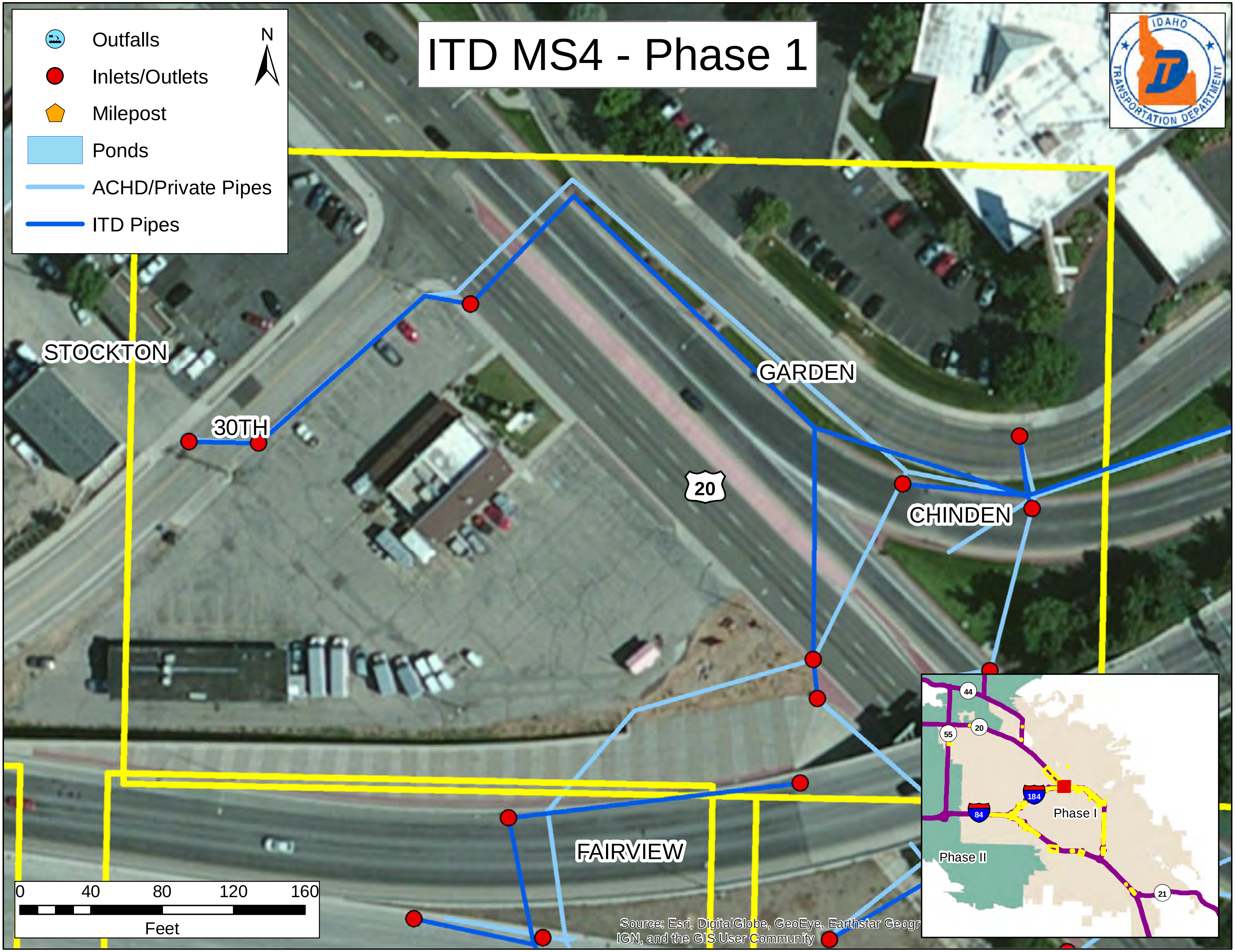
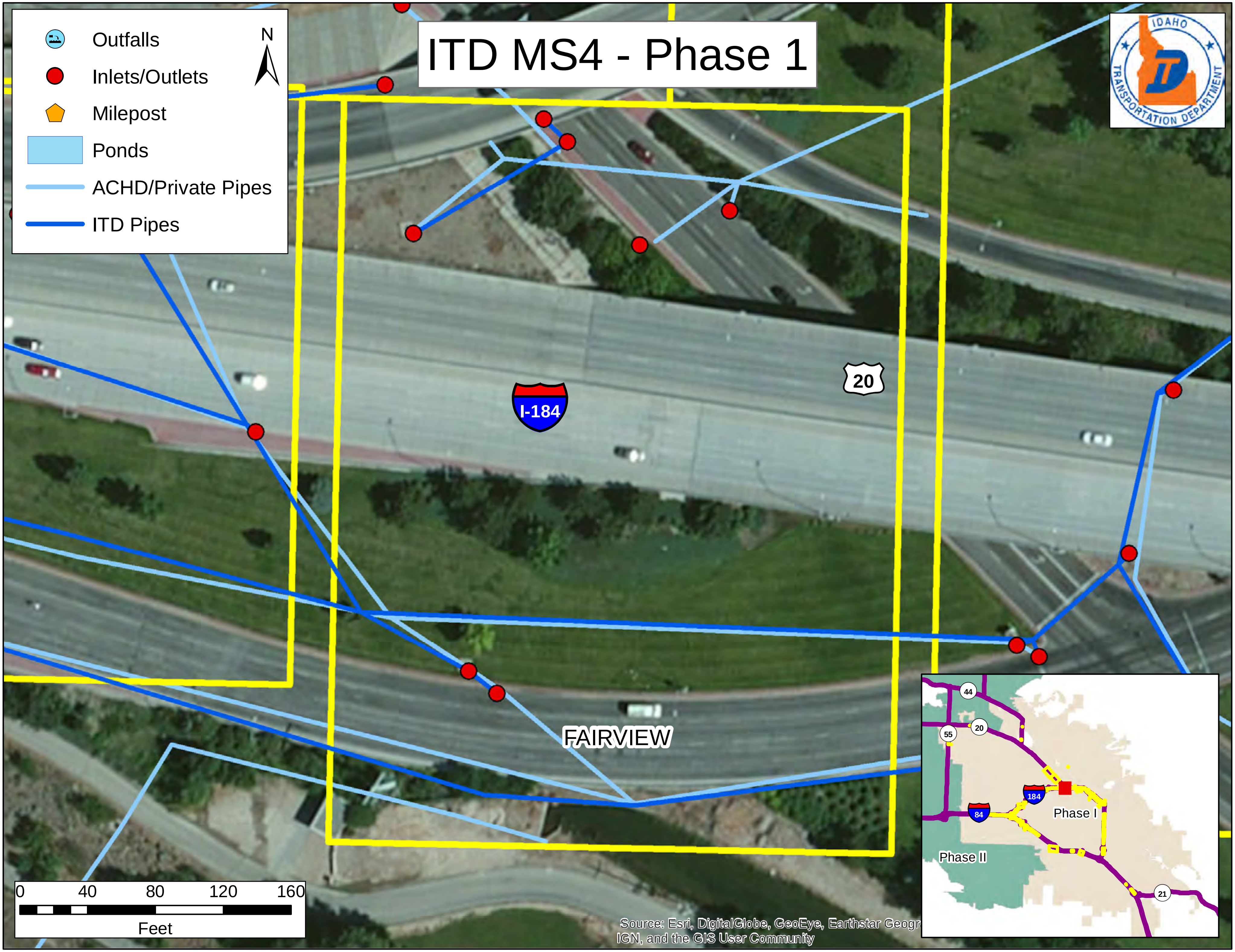

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
STOCKTON
30TH
GARDEN
20
CHINDEN
FAIRVIEW
0 40 80 120 160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
Datum: NAD83

ITD MS4 - Phase 1



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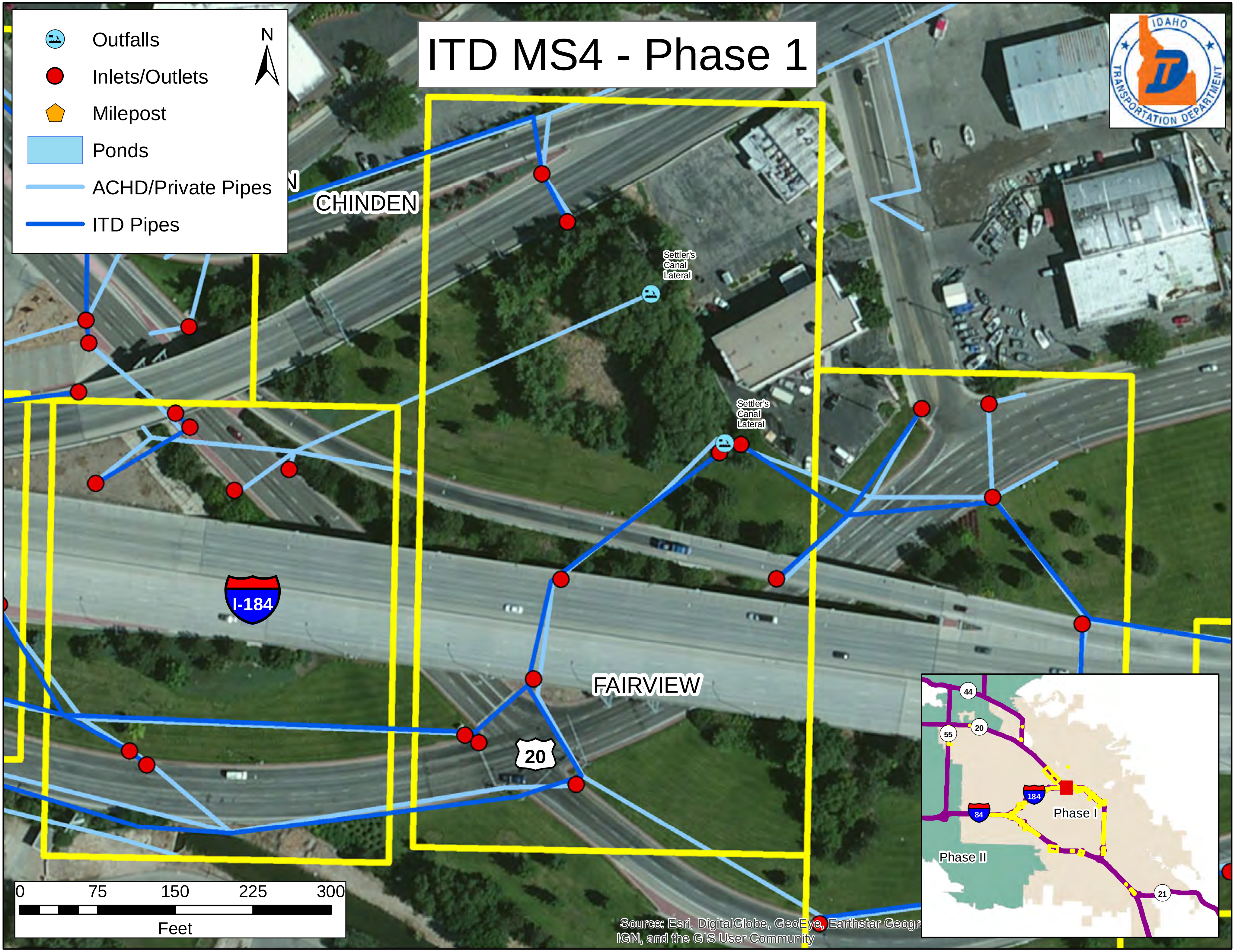
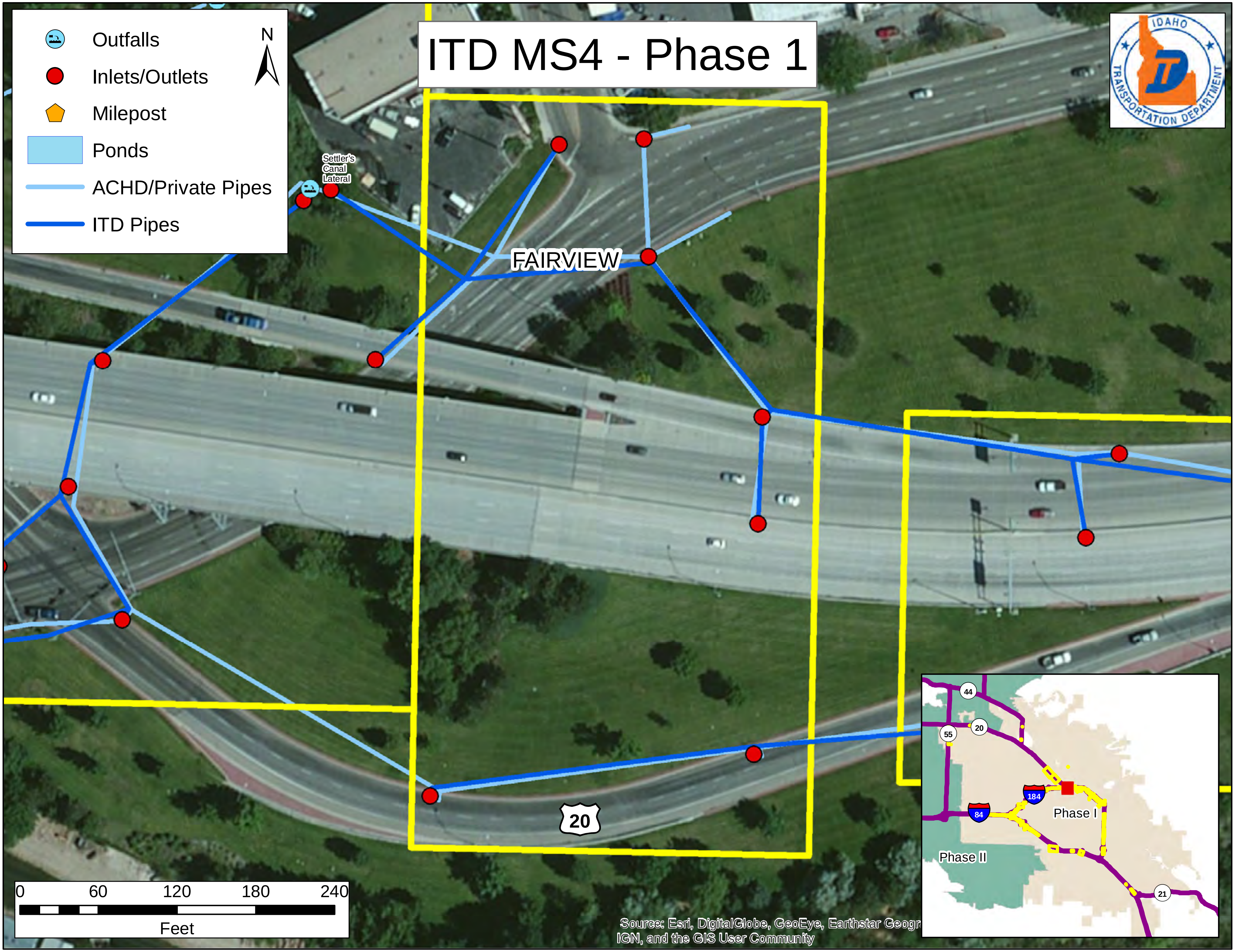
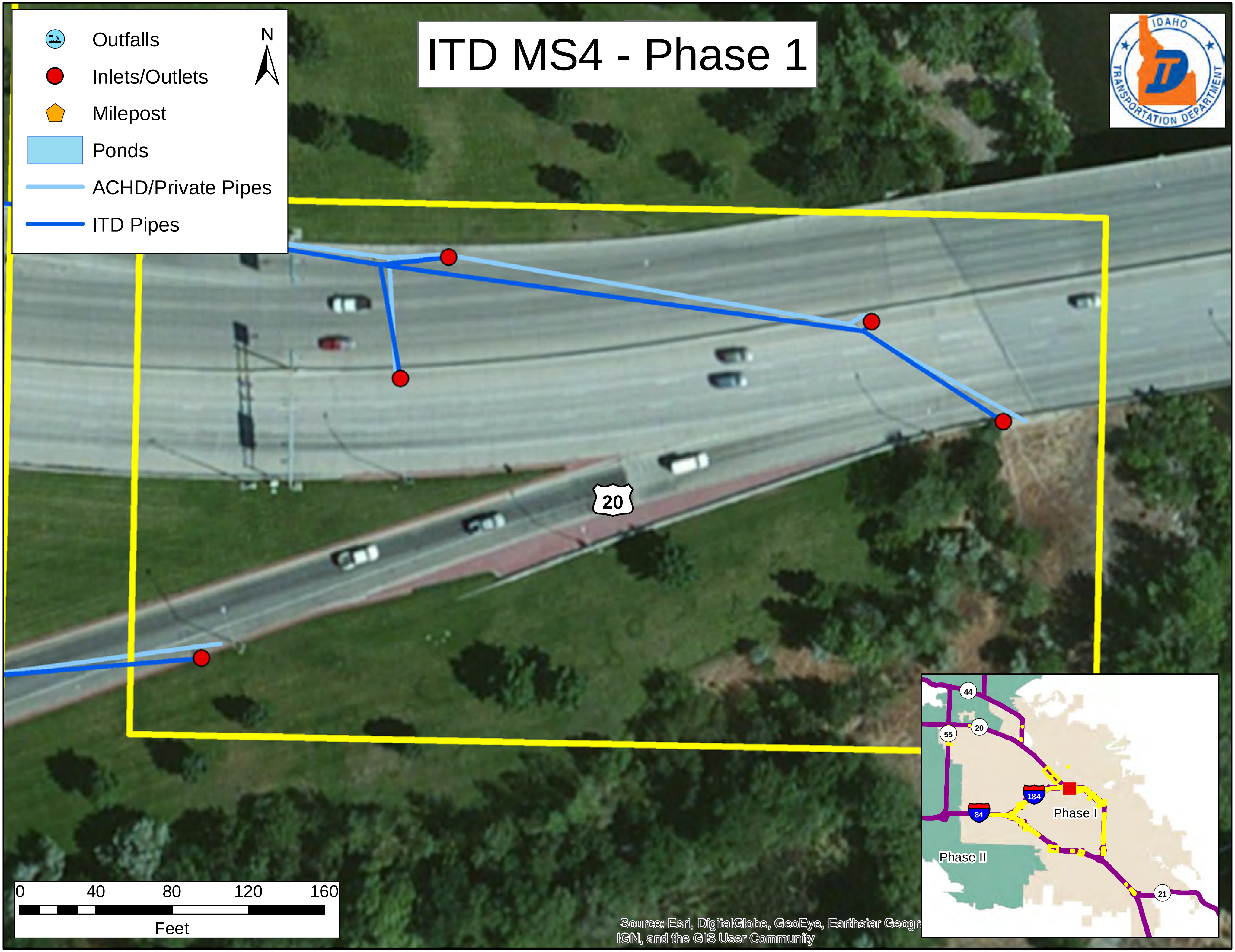
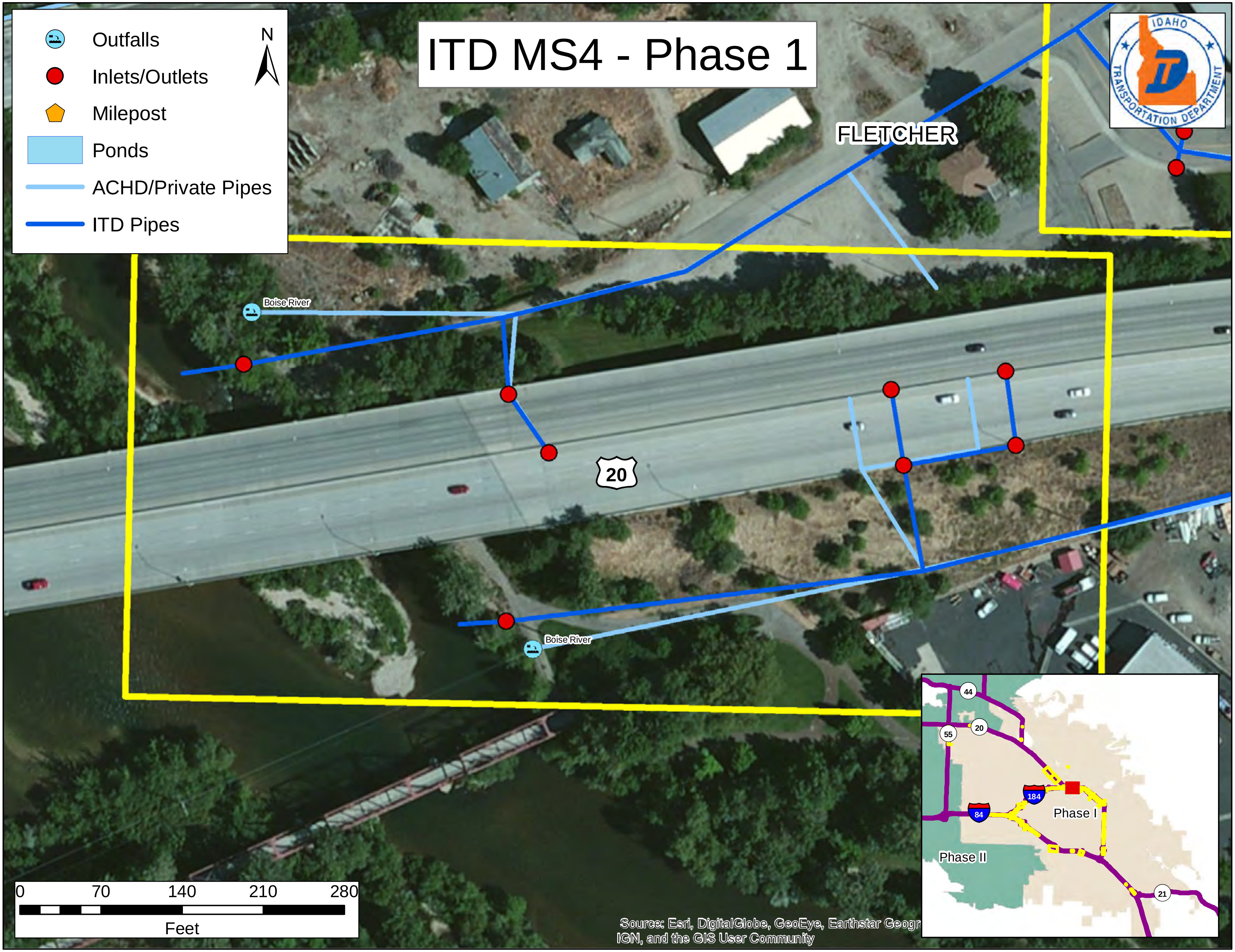

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
CHINDEN
Settler's Canal Lateral
Settler's Canal Lateral
I-184
FAIRVIEW
20
0 75 150 225 300
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
Settler's Canal Lateral
FAIRVIEW
20
0 60 120 180 240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT
Datum: NAD83

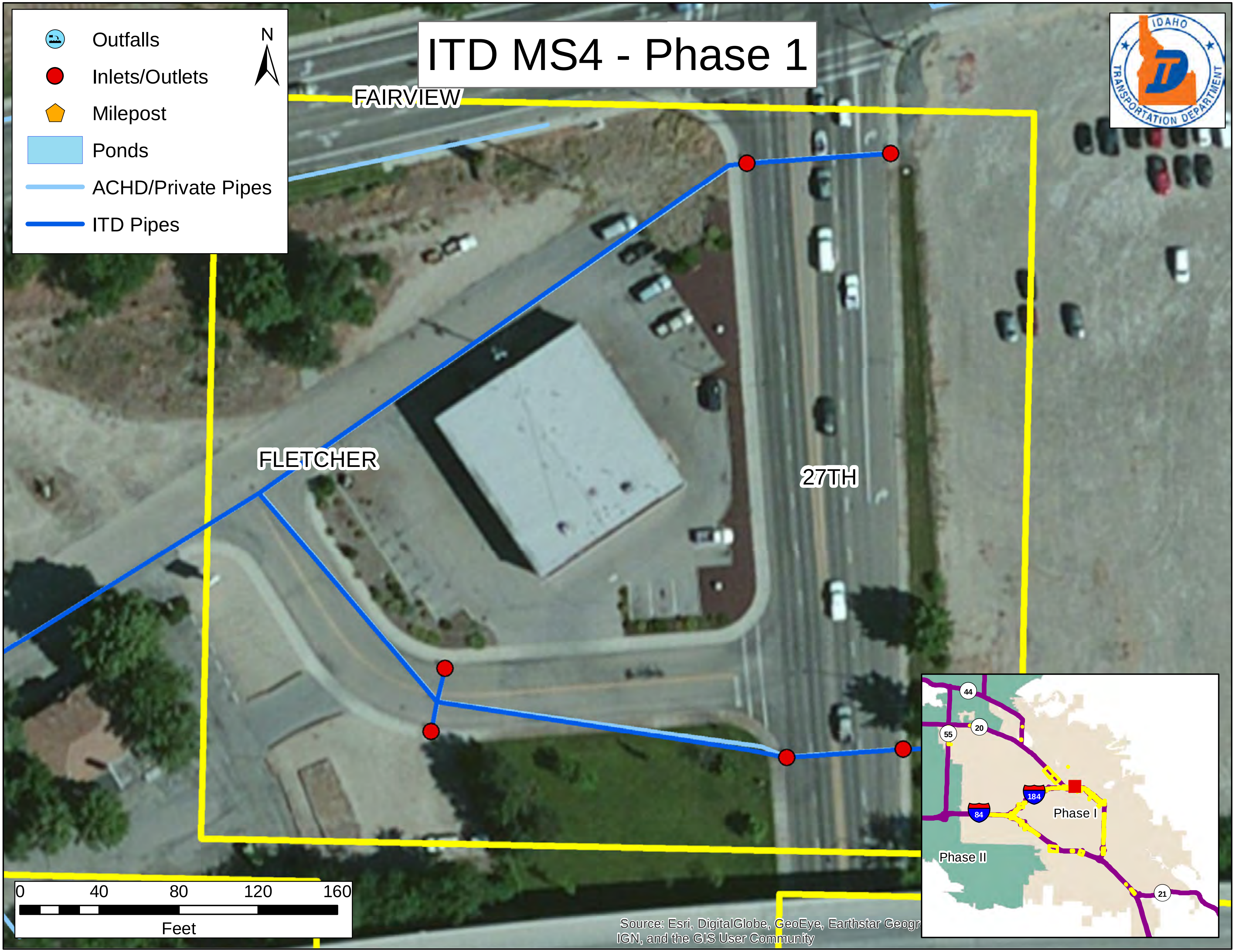

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
20
0 40 80 120 160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

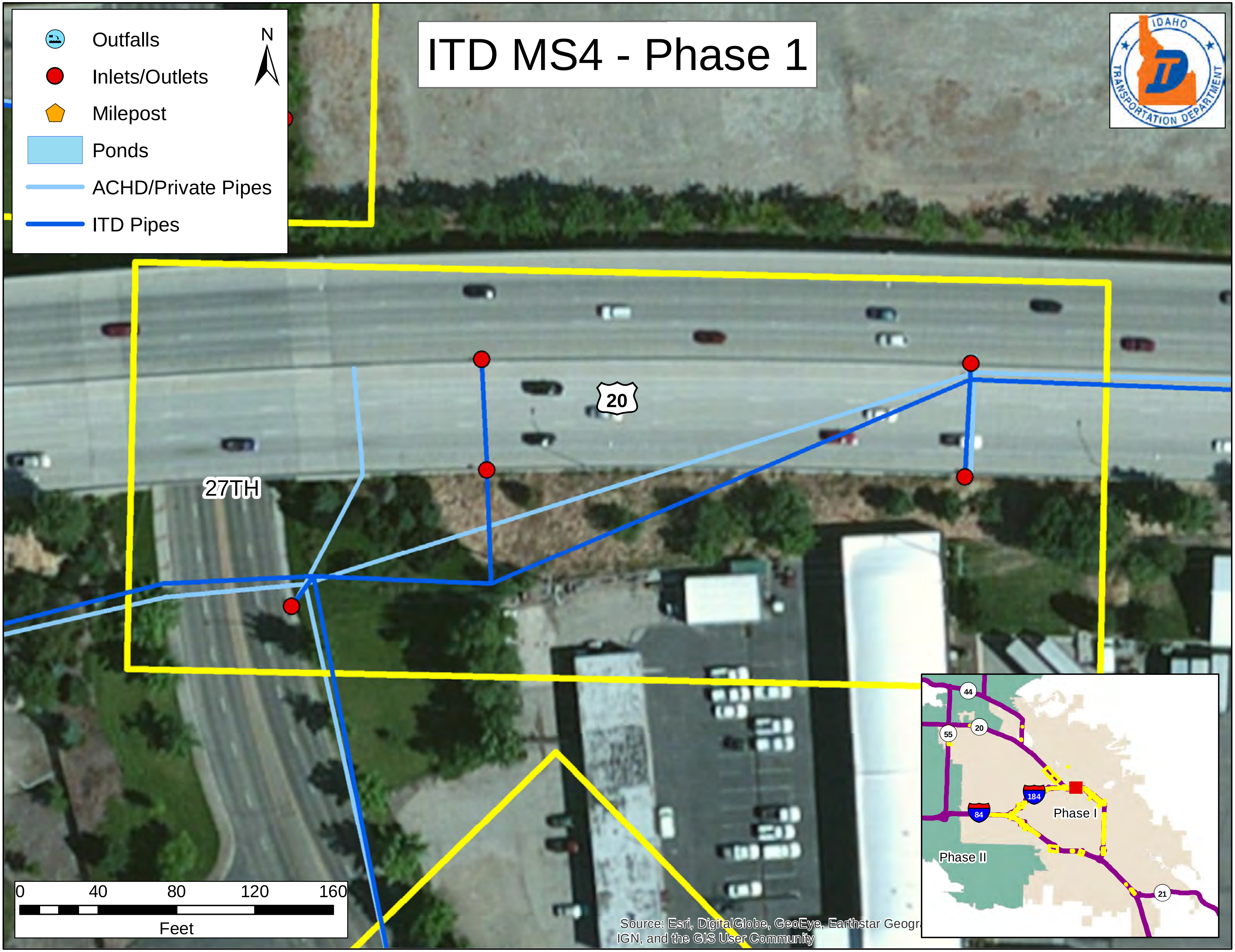


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
FLETCHER
Boise River
Boise River
20
0 70 140 210 280
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
FAIRVIEW
FLETCHER
27TH
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
21
Phase I
Phase II

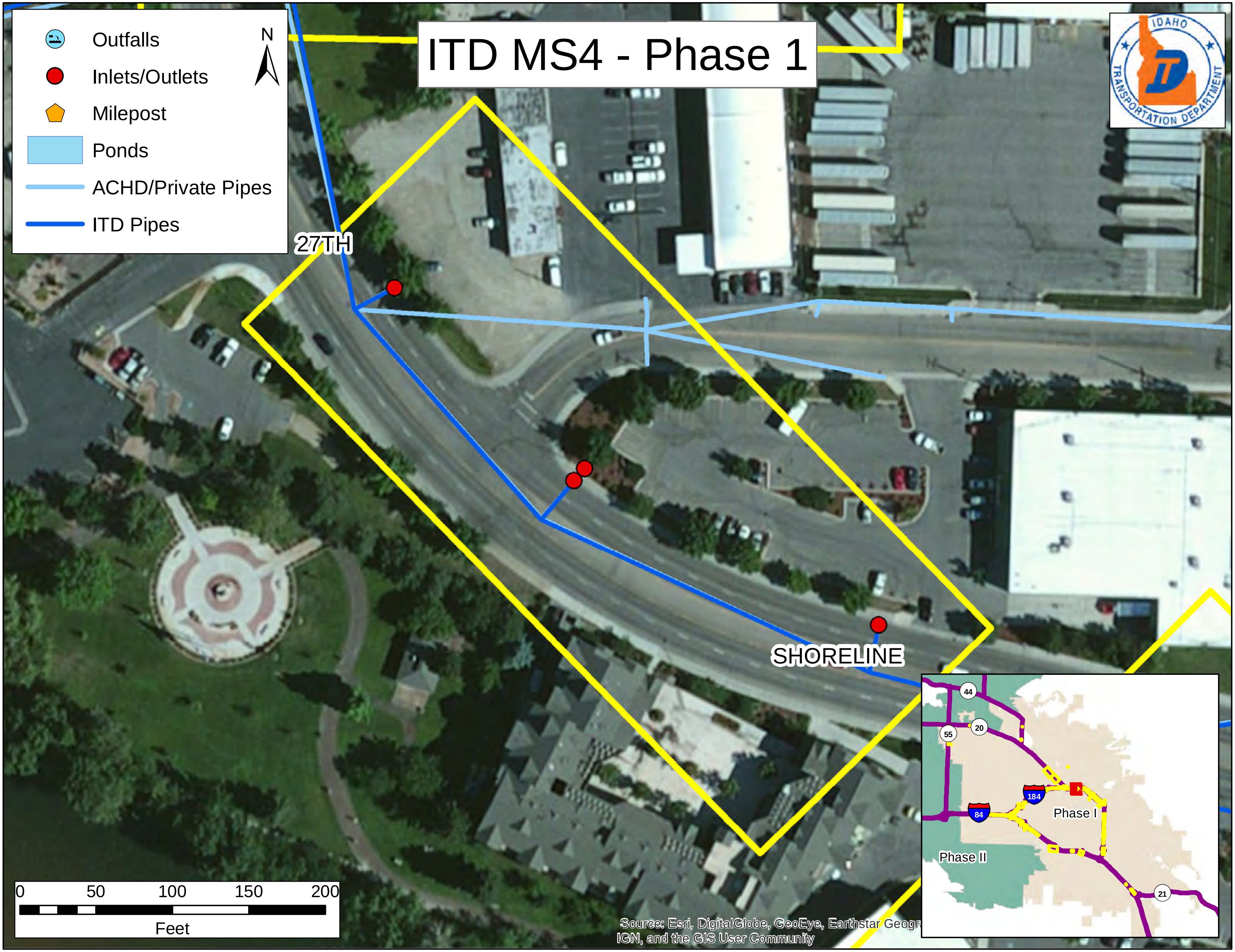
Datum: NAD83



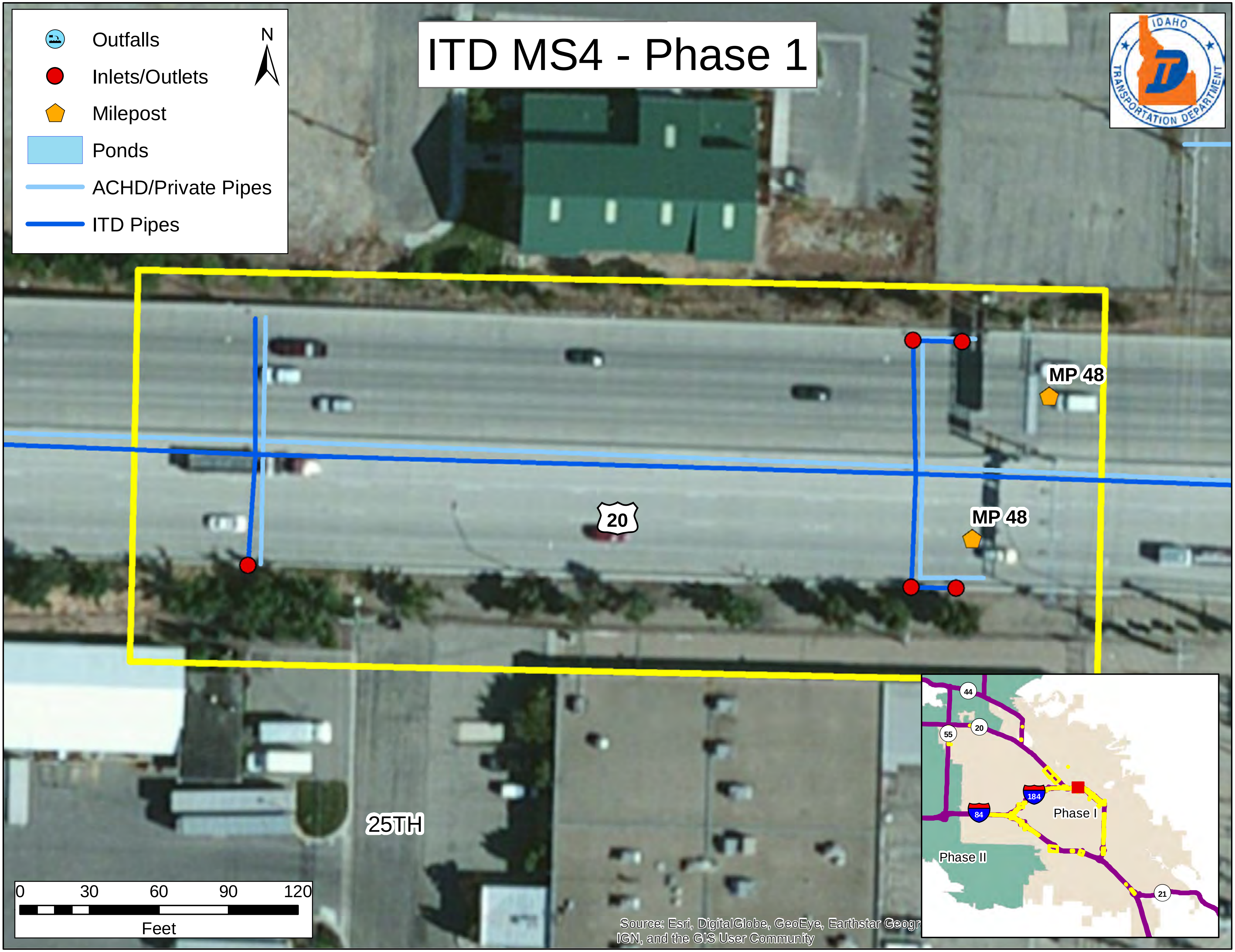
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
20
27TH
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

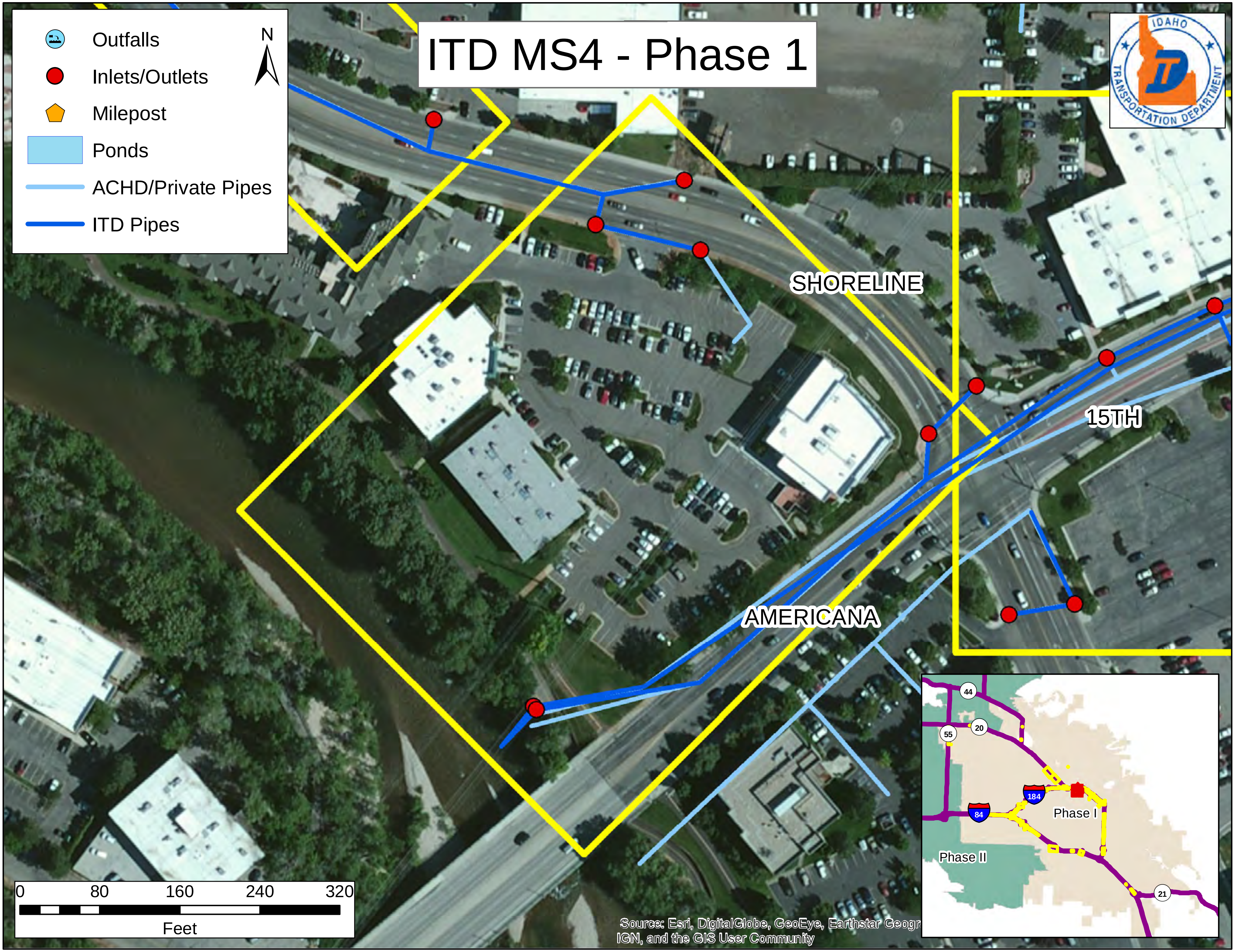
ITD MS4 - Phase 1

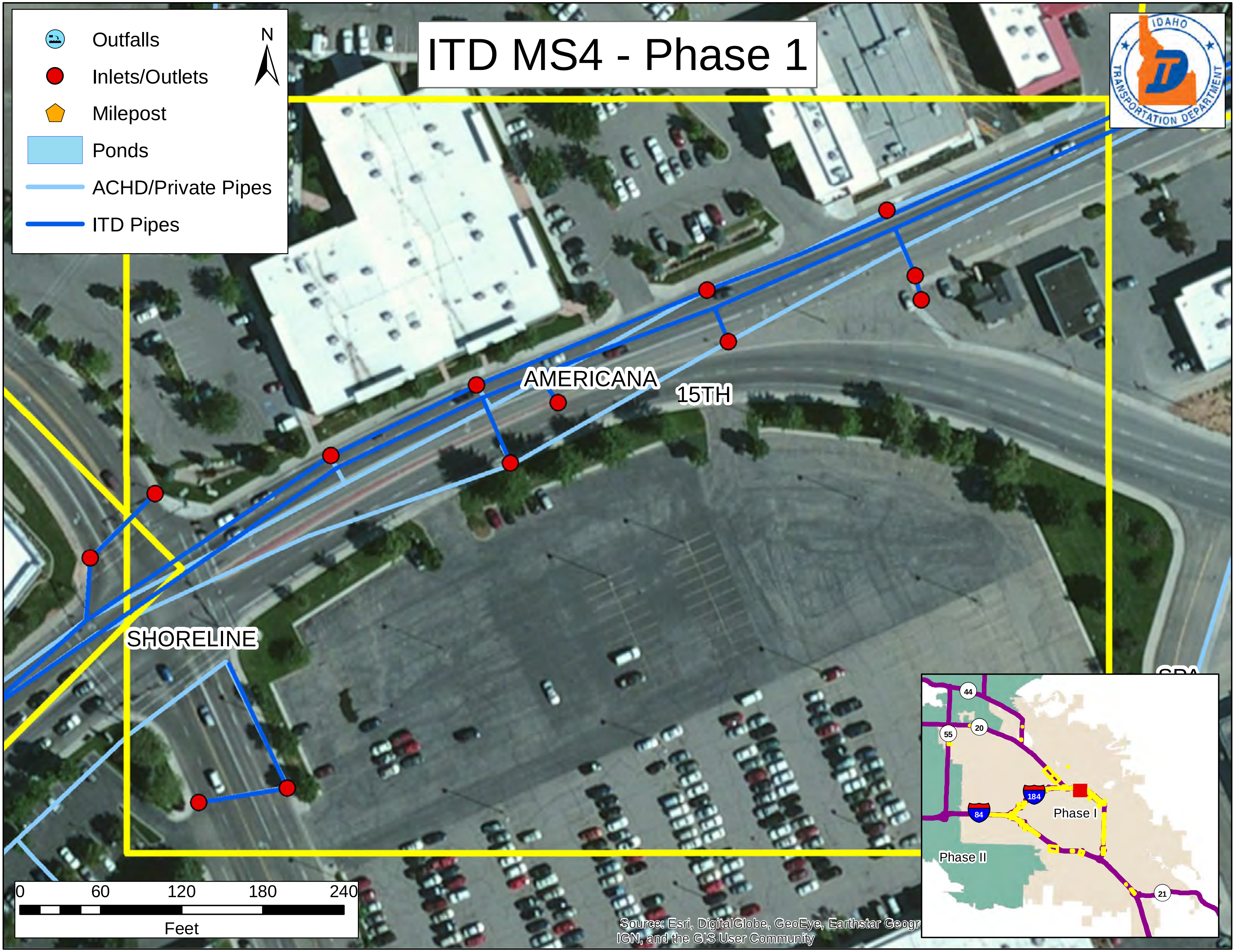


Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
MP 48
MP 48
20
25TH
0 30 60 90 120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
21
Phase I
Phase II

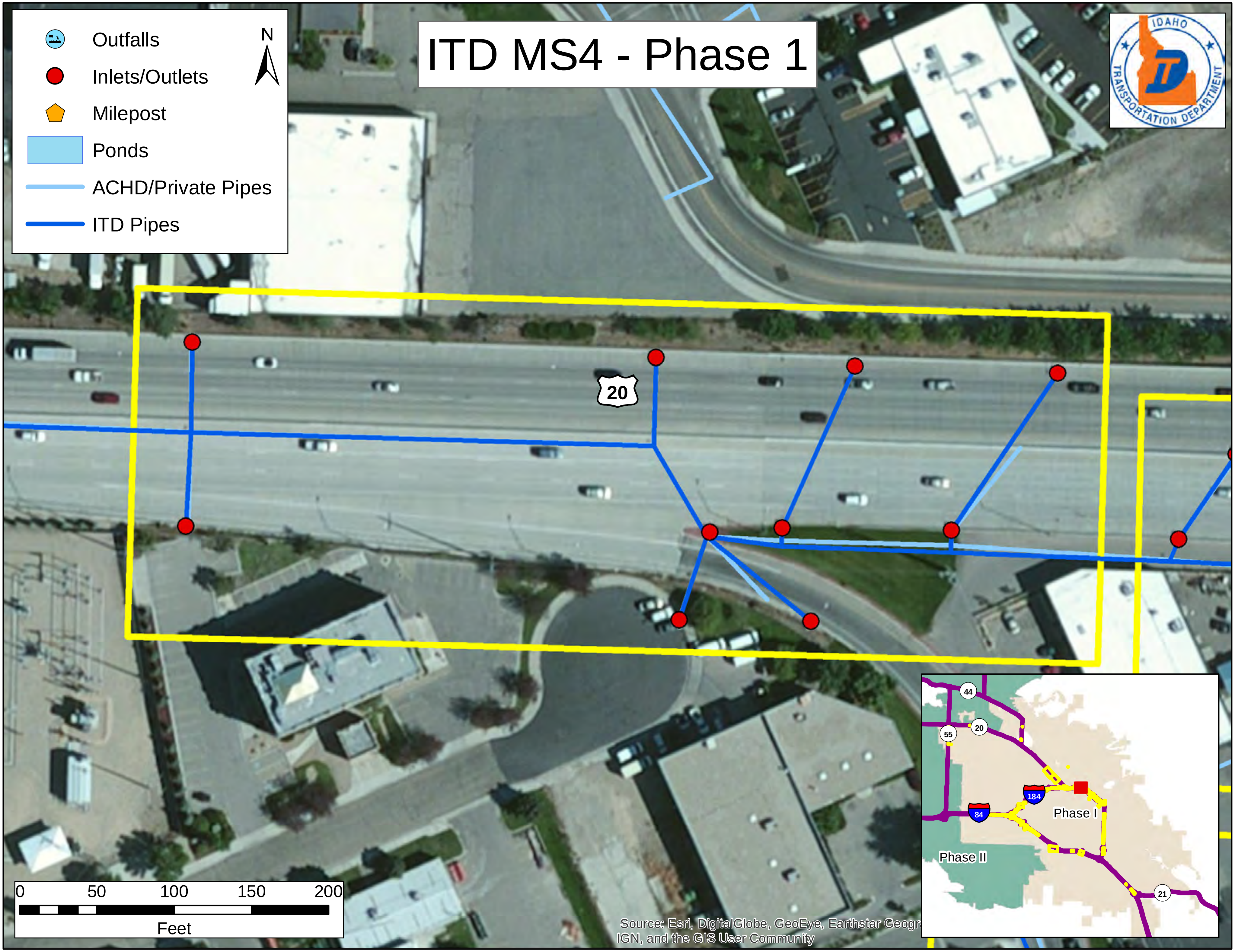
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
SHORELINE
15TH
AMERICANA
0
80
160
240
320
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Datum: NAD83



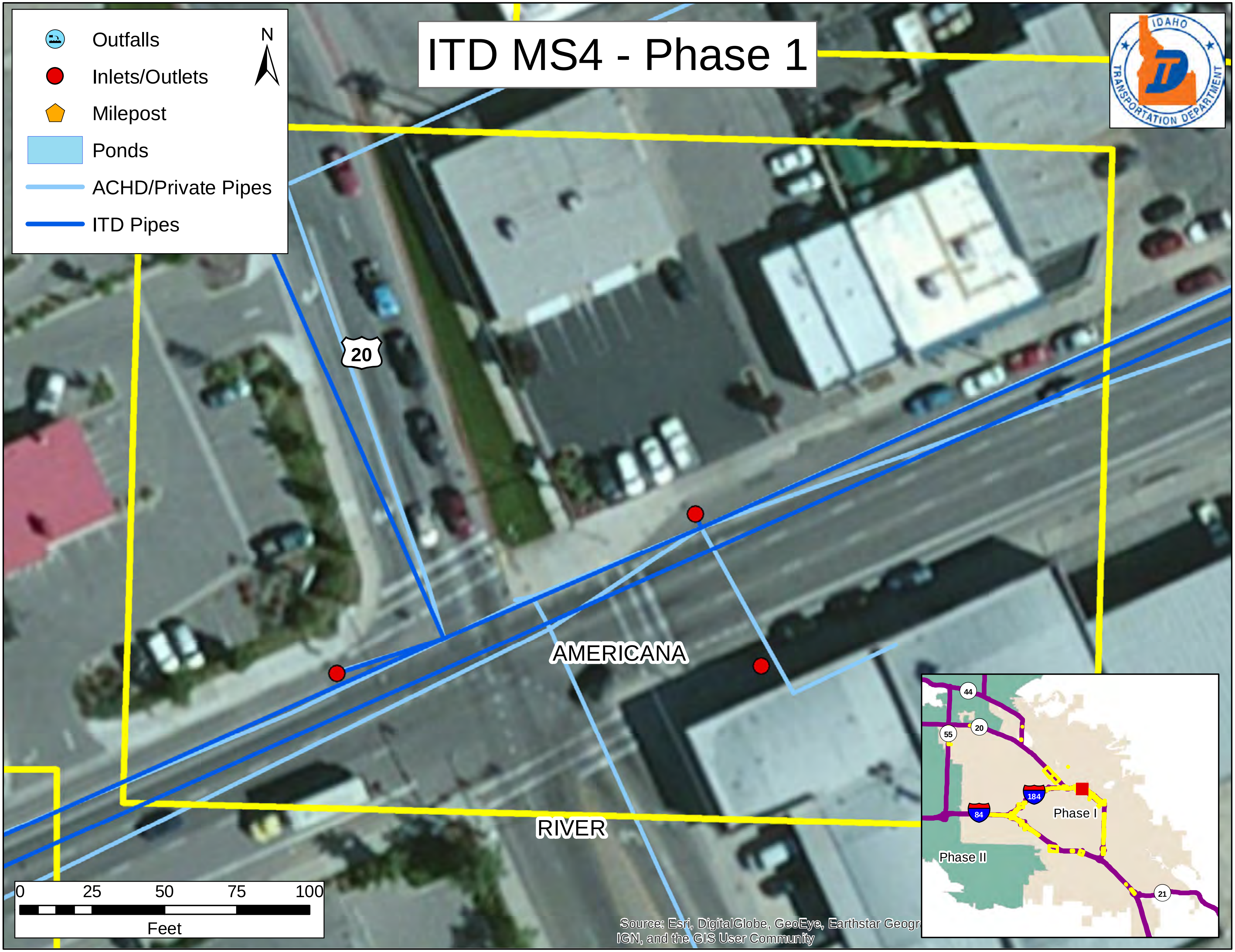
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
AMERICANA
15TH
SHORELINE
0
60
120
180
240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

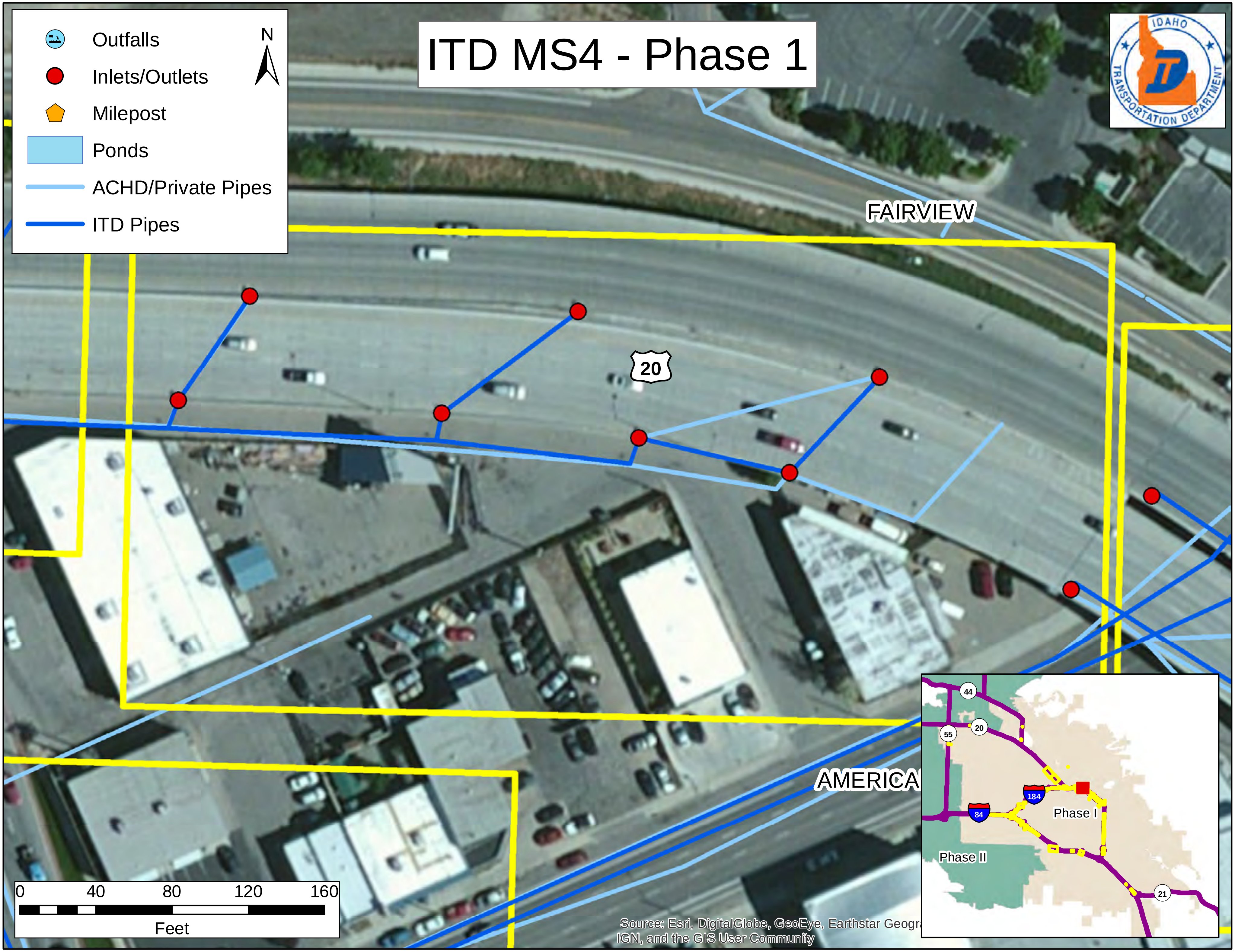


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
20
IDAHO
TRANSPORTATION DEPARTMENT
0
50
100
150
200
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
20
AMERICANA
RIVER
0
25
50
75
100
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
FAIRVIEW
20
AMERICA
44
20
55
184
84
Phase I
Phase II
21
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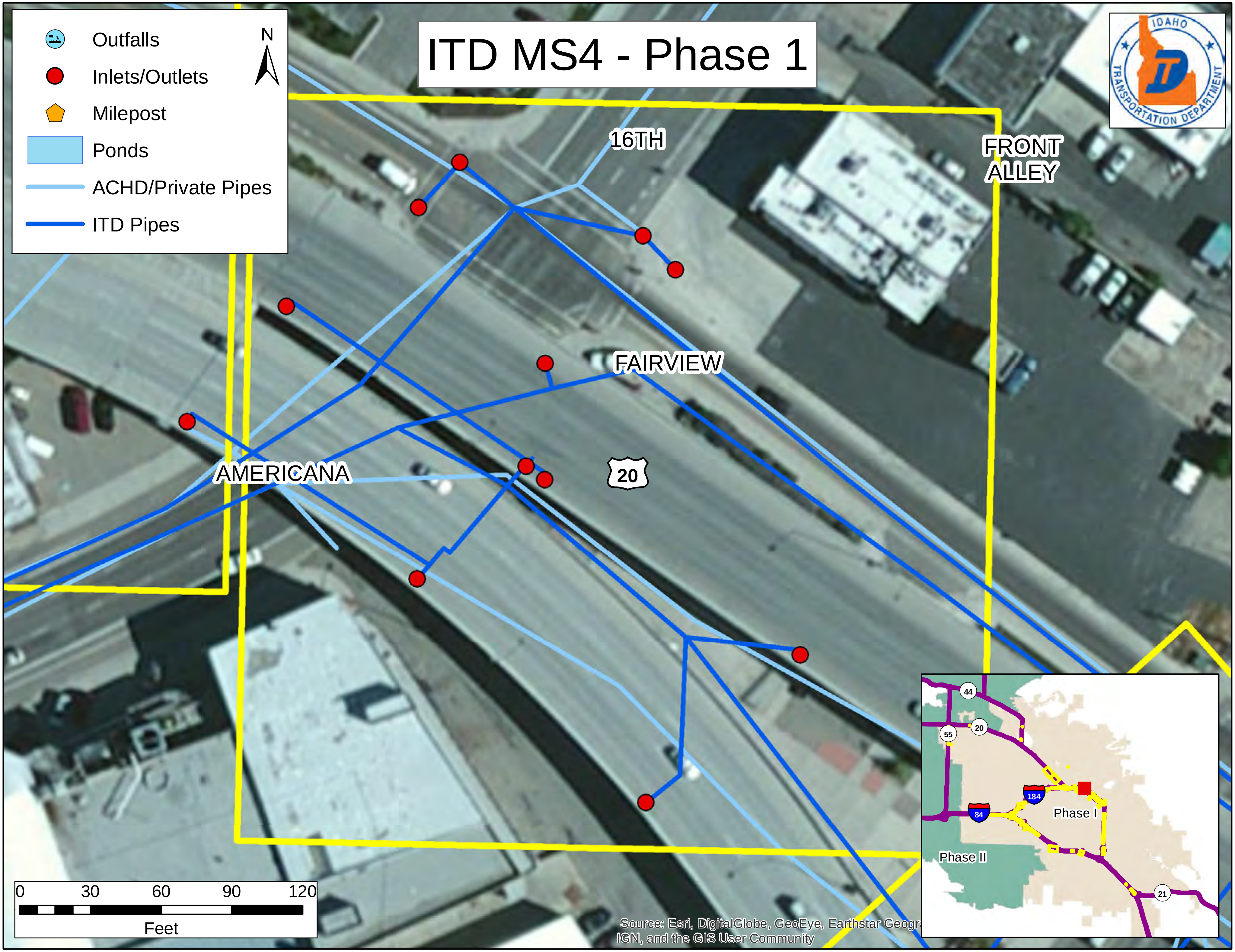
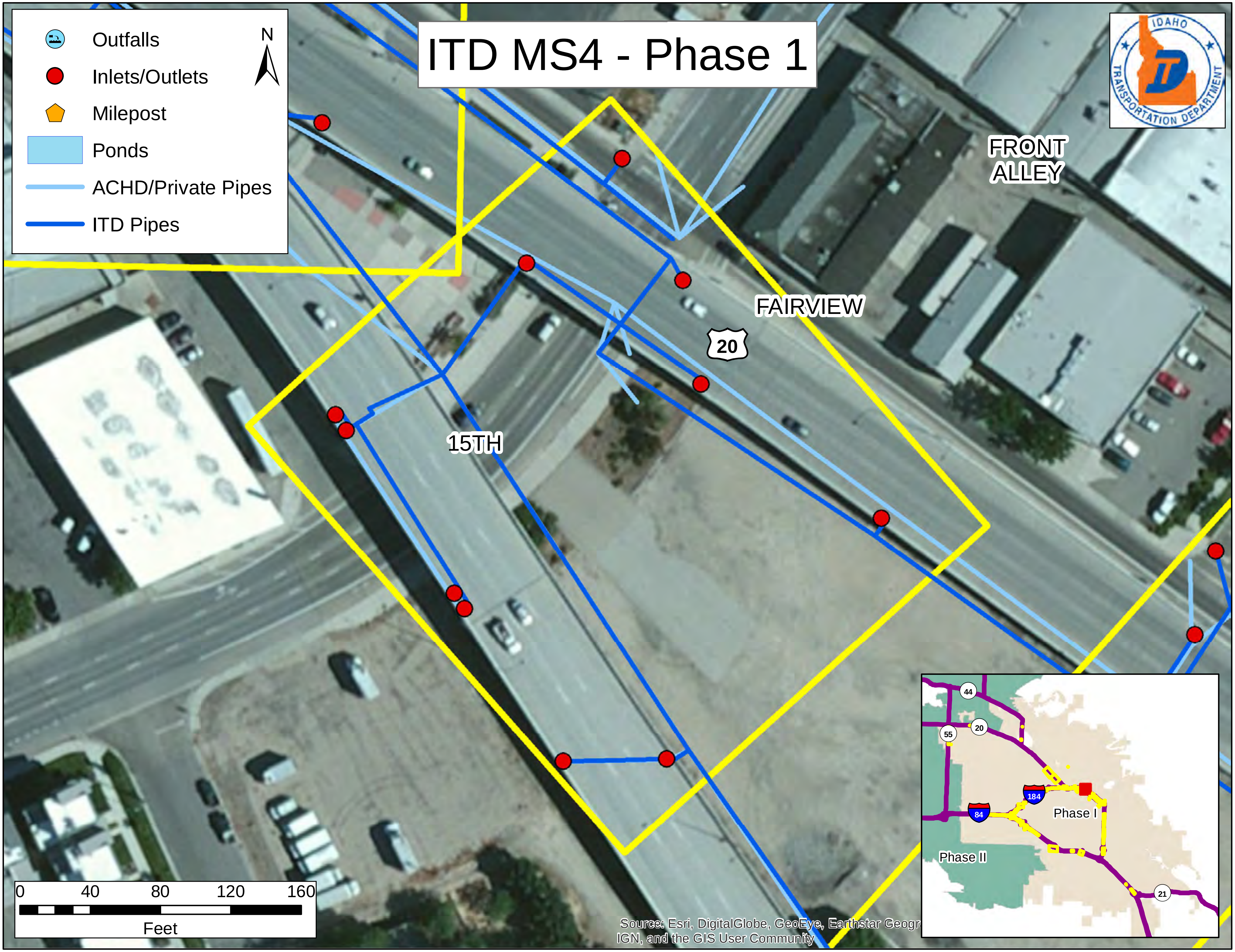
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
16TH
FRONT ALLEY
FAIRVIEW
AMERICANA
20
0 30 60 90 120
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
21
Phase I
Phase II
IDAHO TRANSPORTATION DEPARTMENT
Datum: NAD83

ITD MS4 - Phase 1



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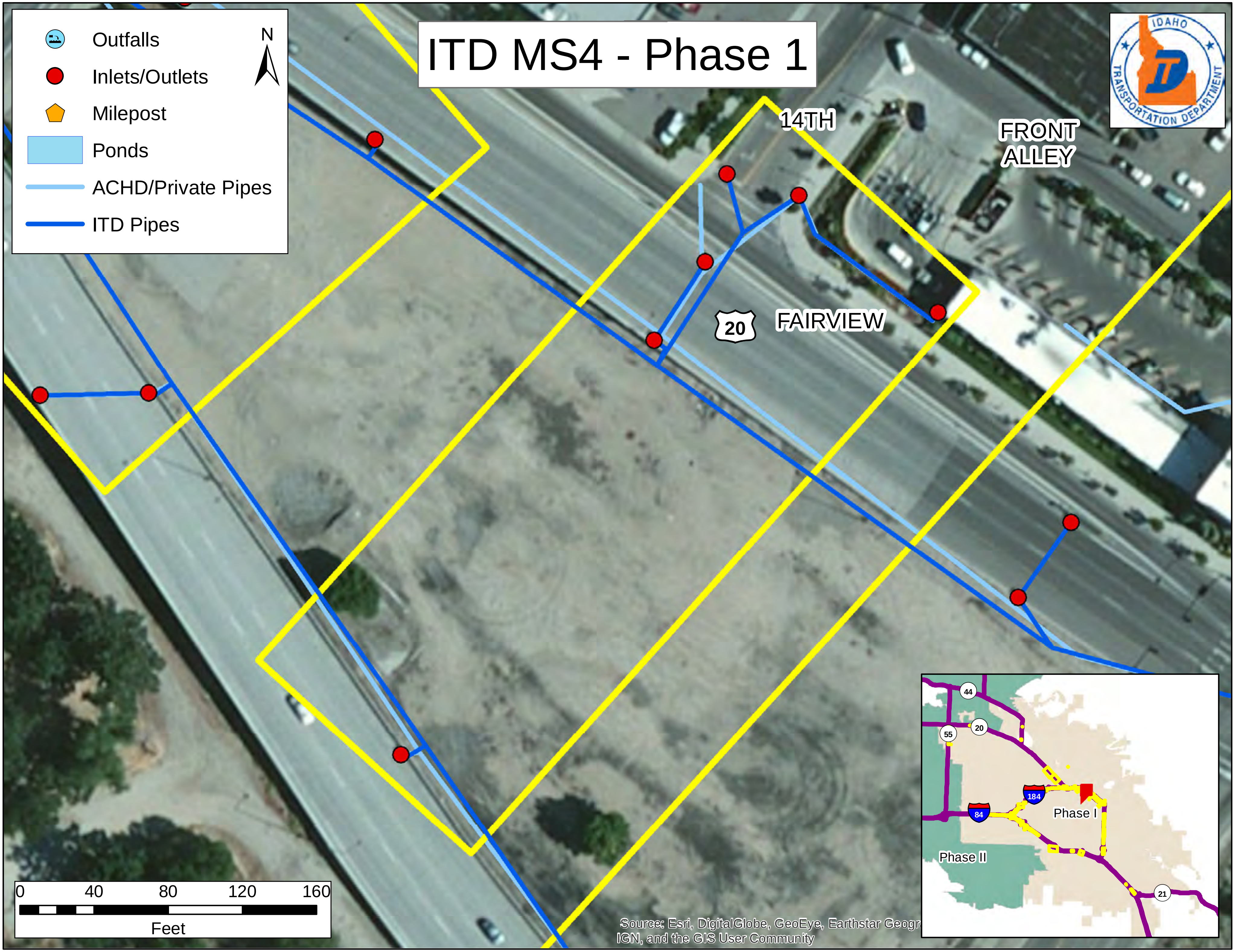
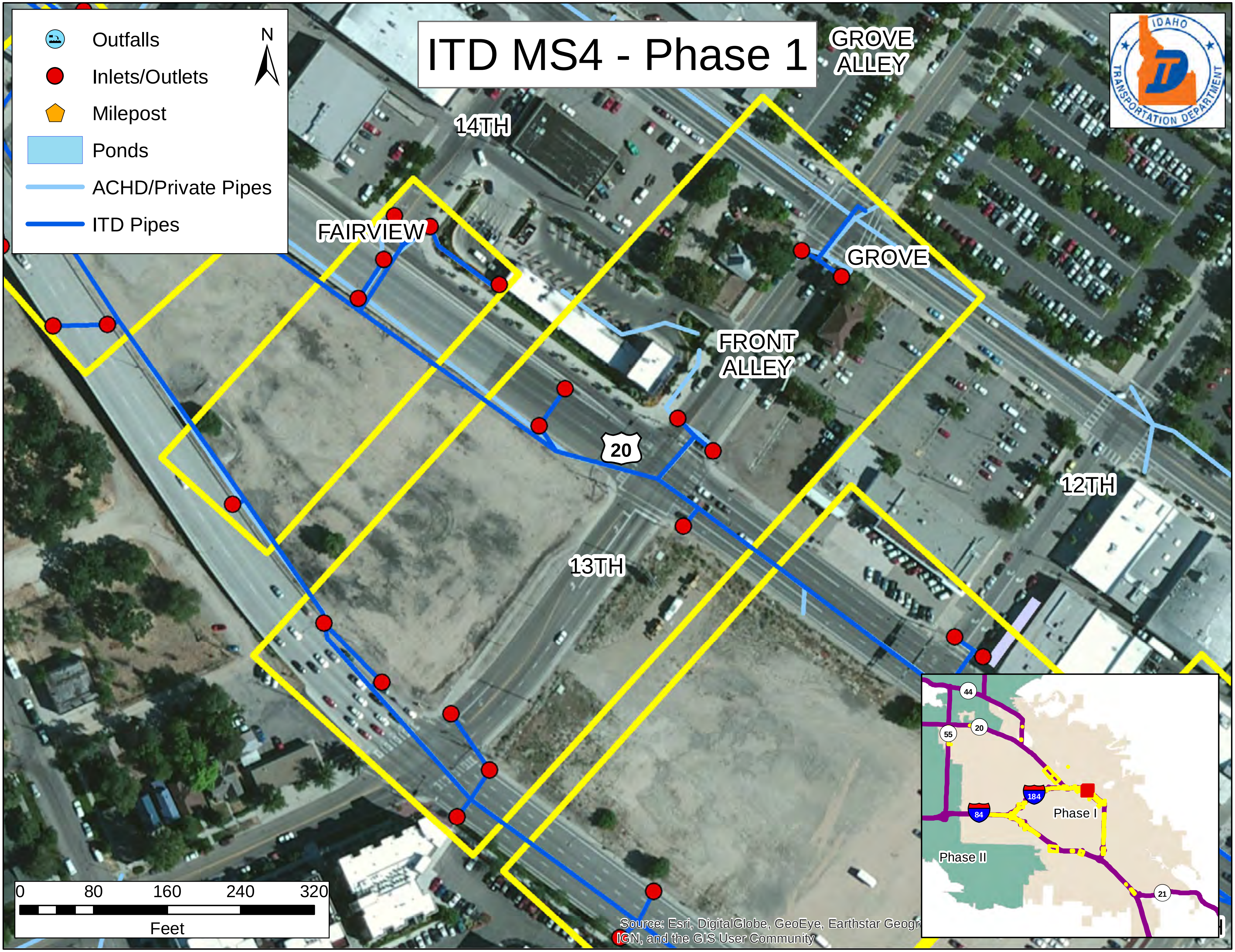


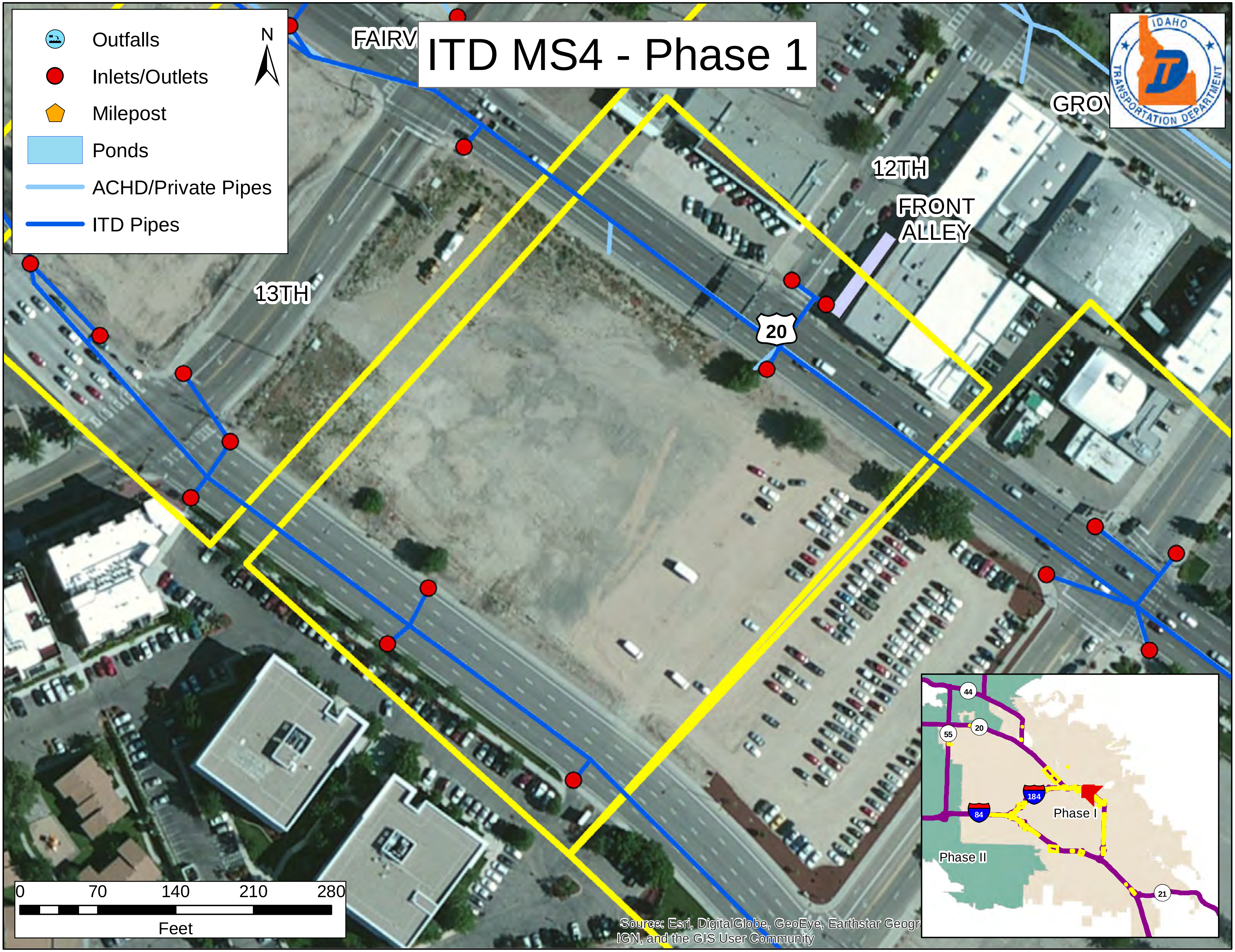
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
14TH
FRONT
ALLEY
20
FAIRVIEW
0
40
80
120
160
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83

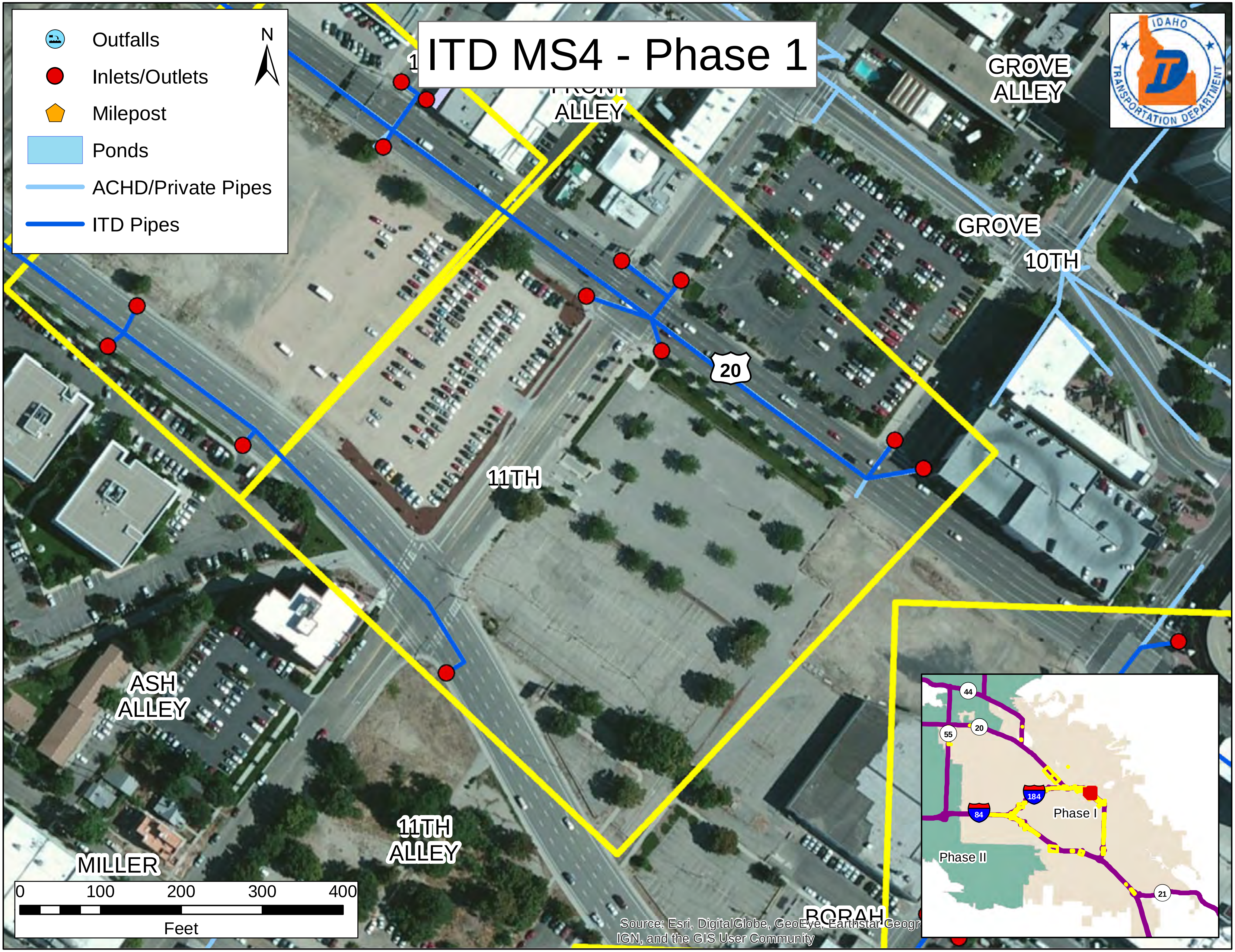


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
GROVE ALLEY
14TH
FAIRVIEW
GROVE
FRONT ALLEY
20
12TH
13TH
0
80
160
240
320
Feet
44
20
55
184
84
Phase I
Phase II
21
IDAHO TRANSPORTATION DEPARTMENT
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
FAIRV
GROV
IDAHO TRANSPORTATION DEPARTMENT
12TH
FRONT ALLEY
13TH
20
0 70 140 210 280
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

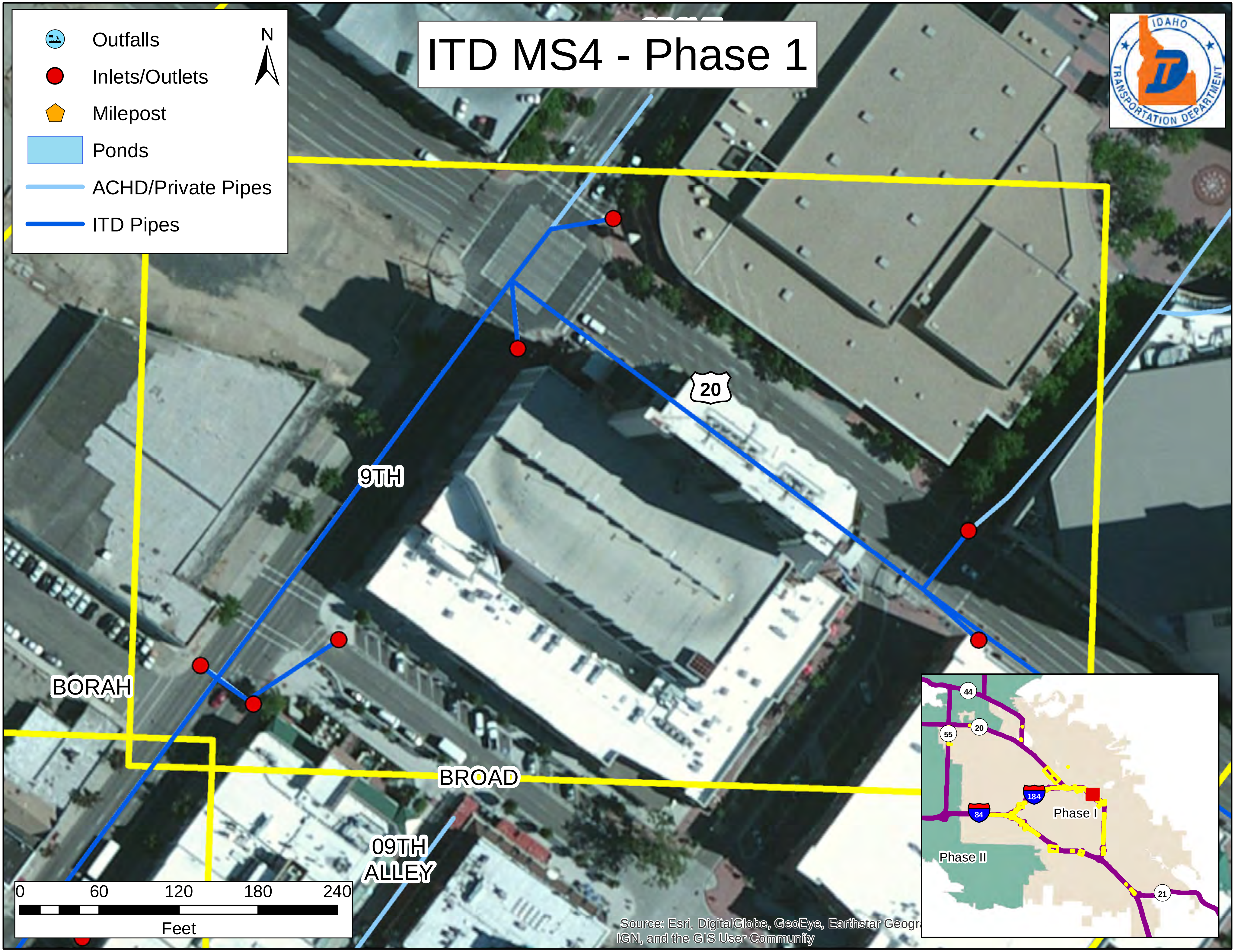
Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
GROVE
ALLEY
ALLEY
GROVE
10TH
20
11TH
ASH
ALLEY
11TH
ALLEY
MILLER
BORAH
0
100
200
300
400
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83

ITD MS4 - Phase 1



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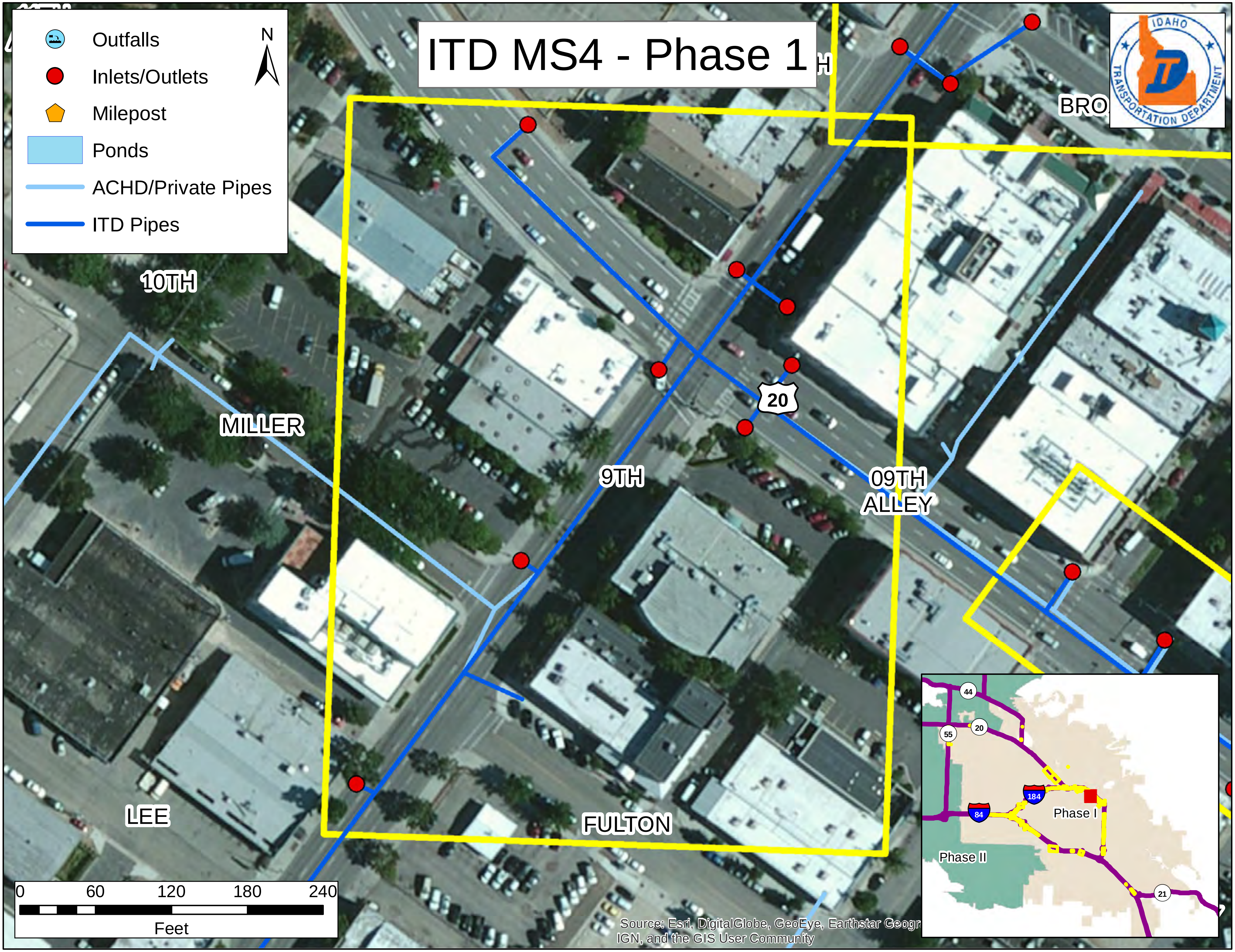
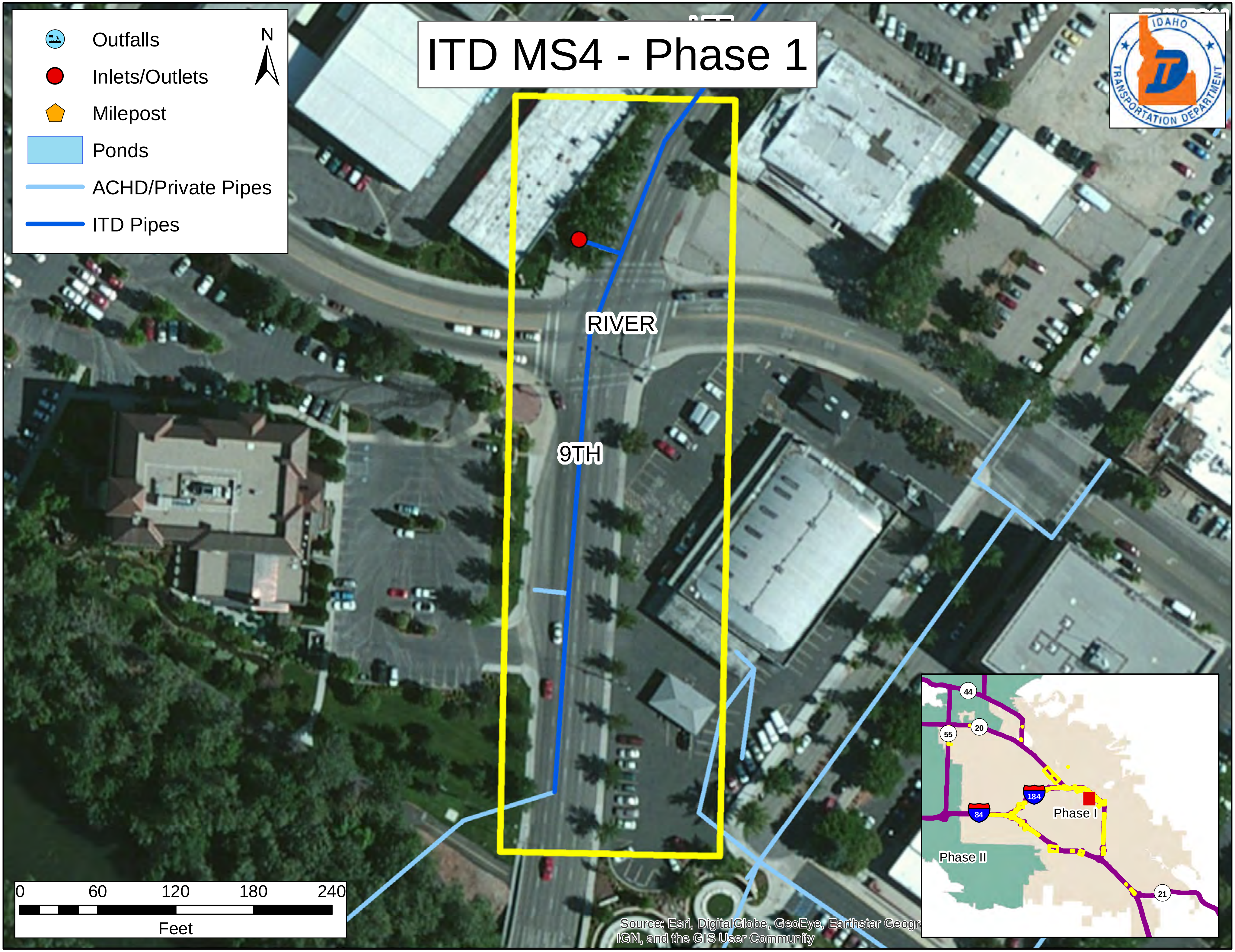
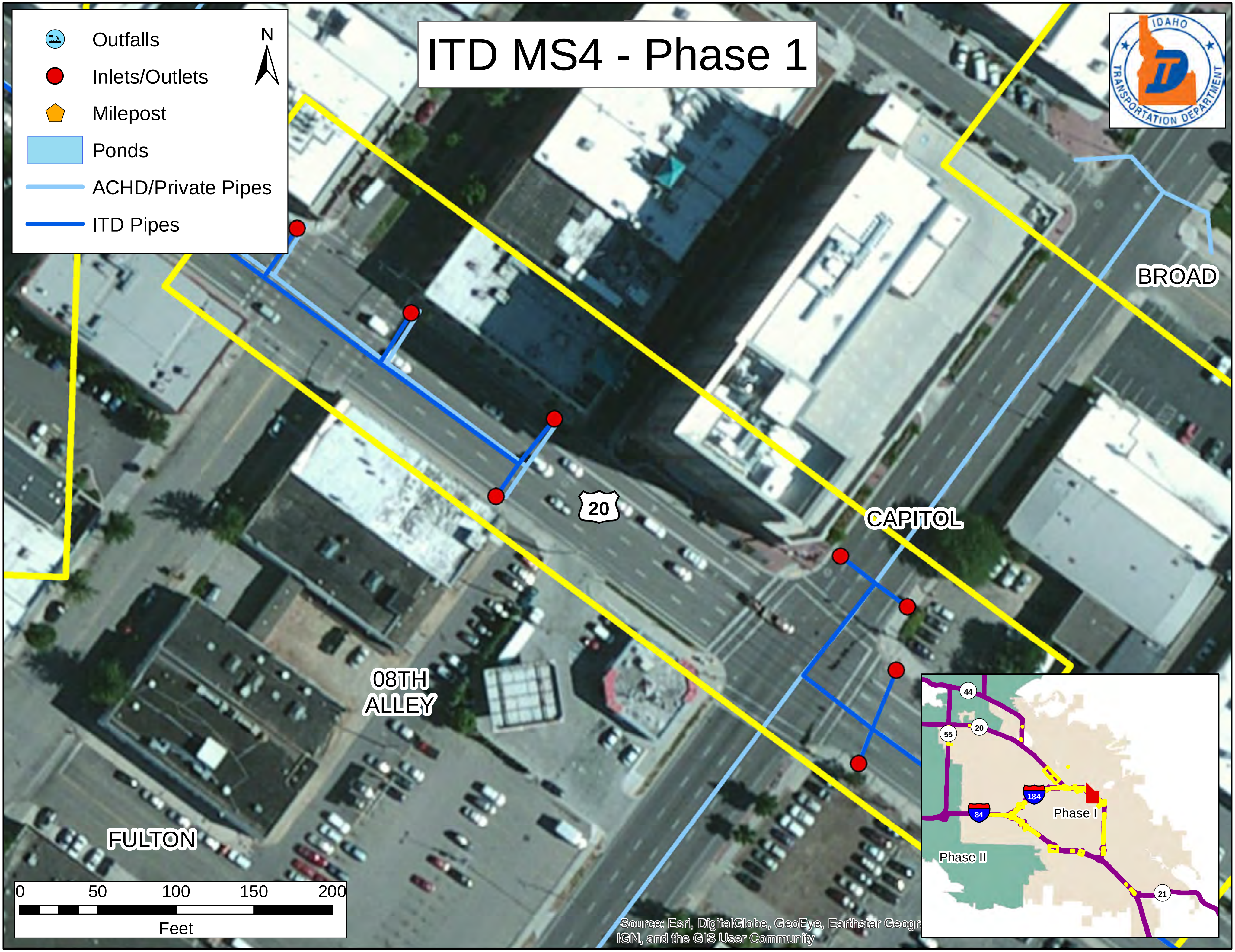


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
BRO
10TH
MILLER
9TH
20
09TH
ALLEY
LEE
FULTON
0 60 120 180 240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83

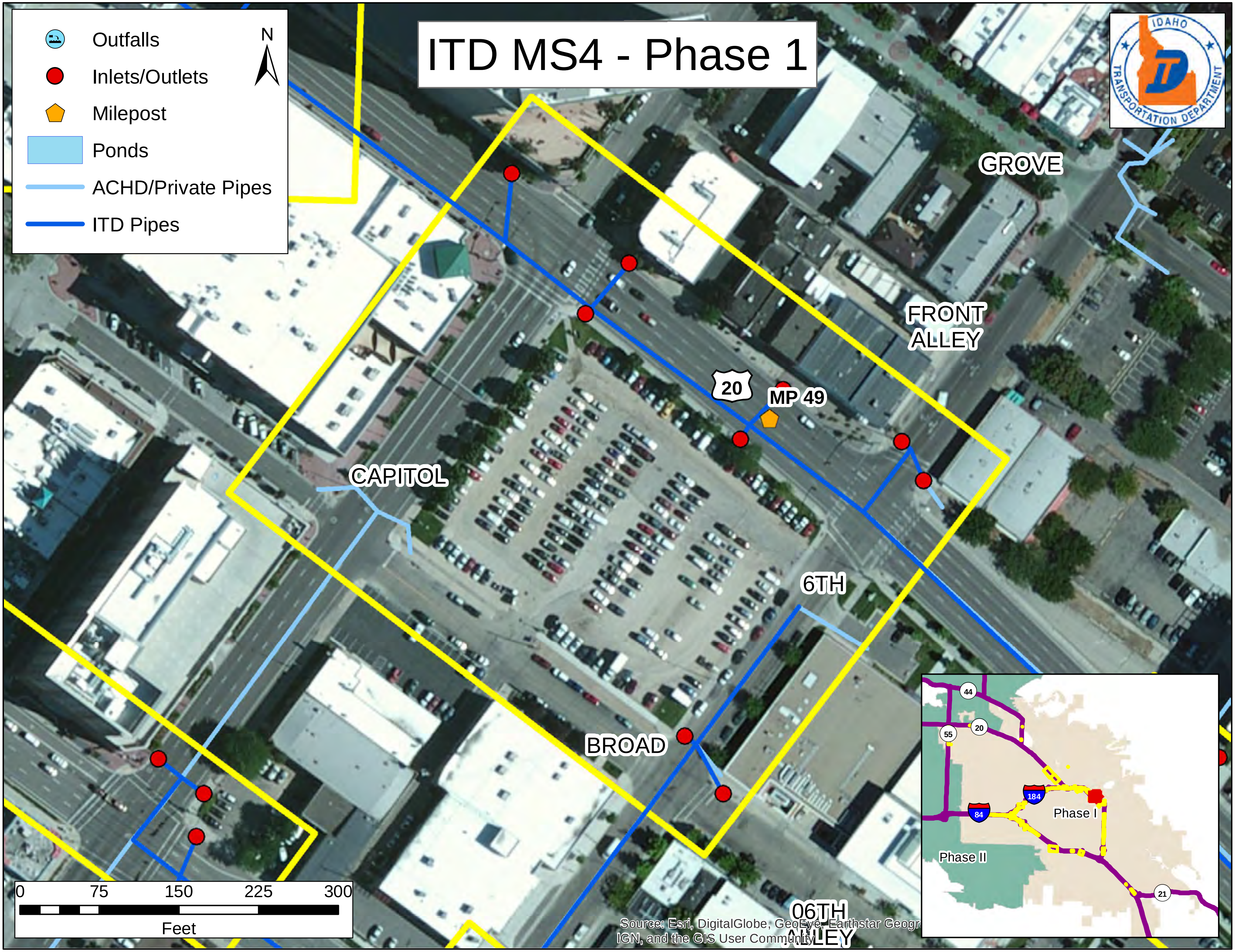

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
RIVER
9TH
0
60
120
180
240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21
IDAHO
TRANSPORTATION DEPARTMENT

Datum: NAD83



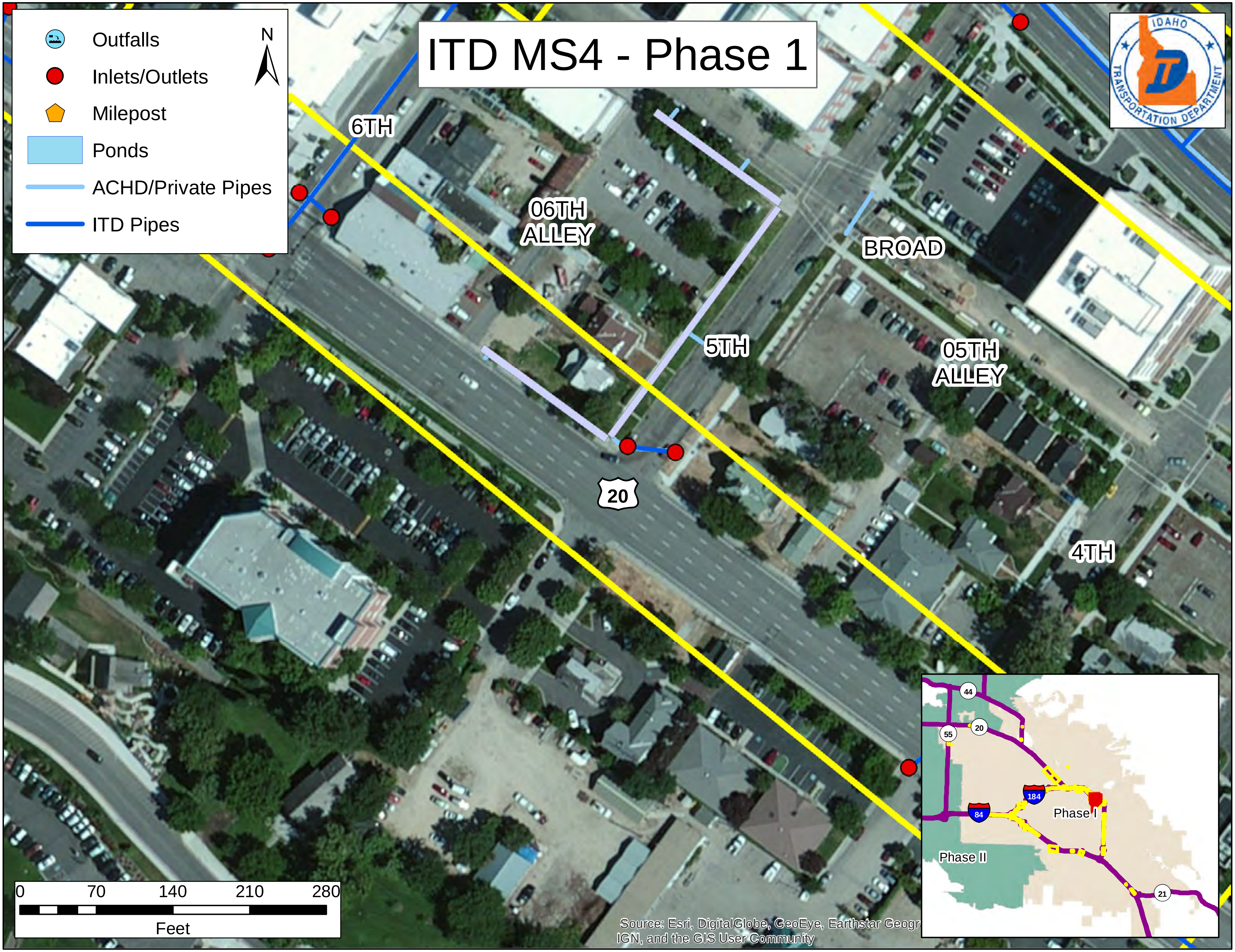
ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
BROAD
CAPITOL
20
08TH
ALLEY
FULTON
0
50
100
150
200
Feet
44
20
55
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83

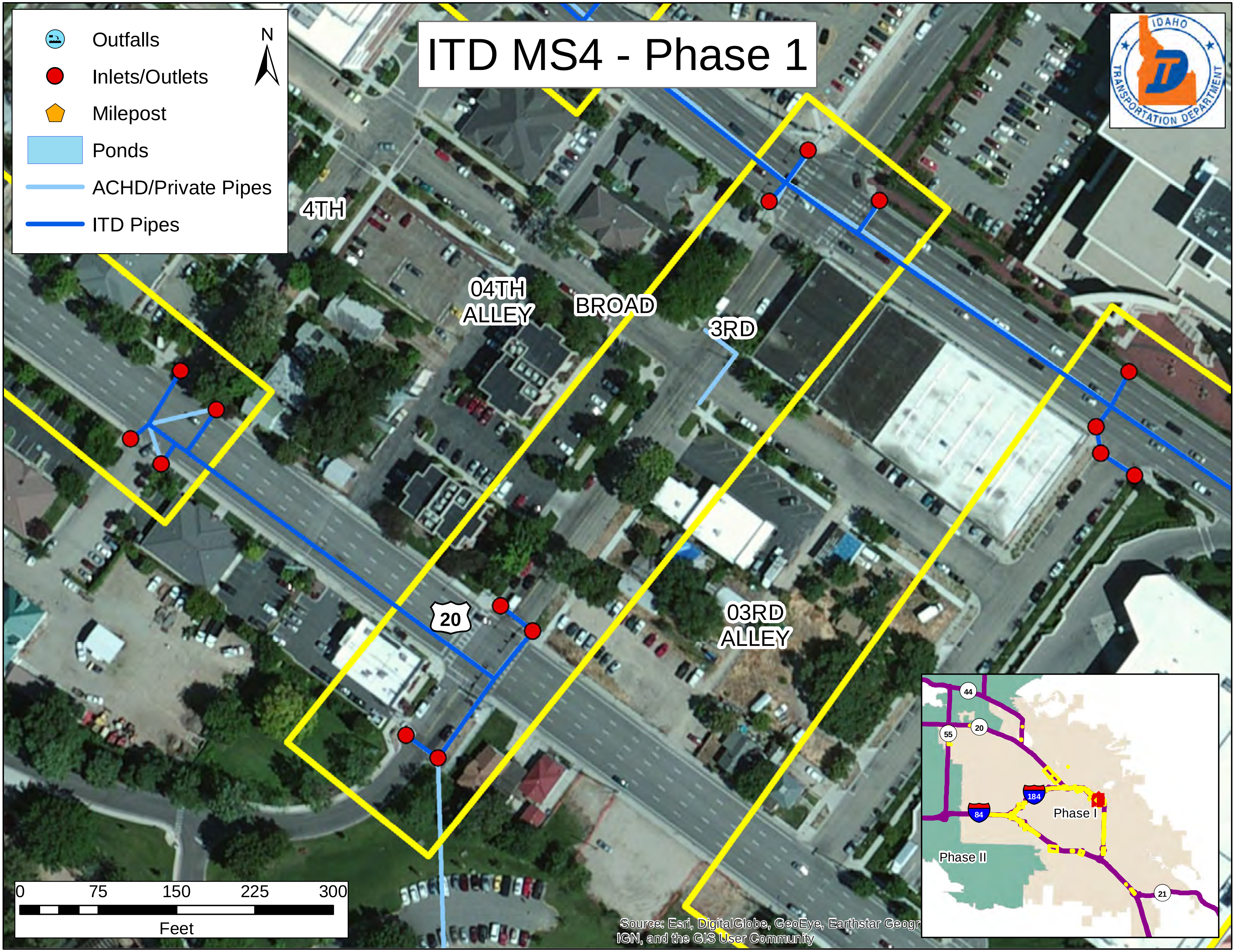


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
GROVE
FRONT ALLEY
20
MP 49
CAPITOL
6TH
BROAD
06TH ALLEY
0 75 150 225 300
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

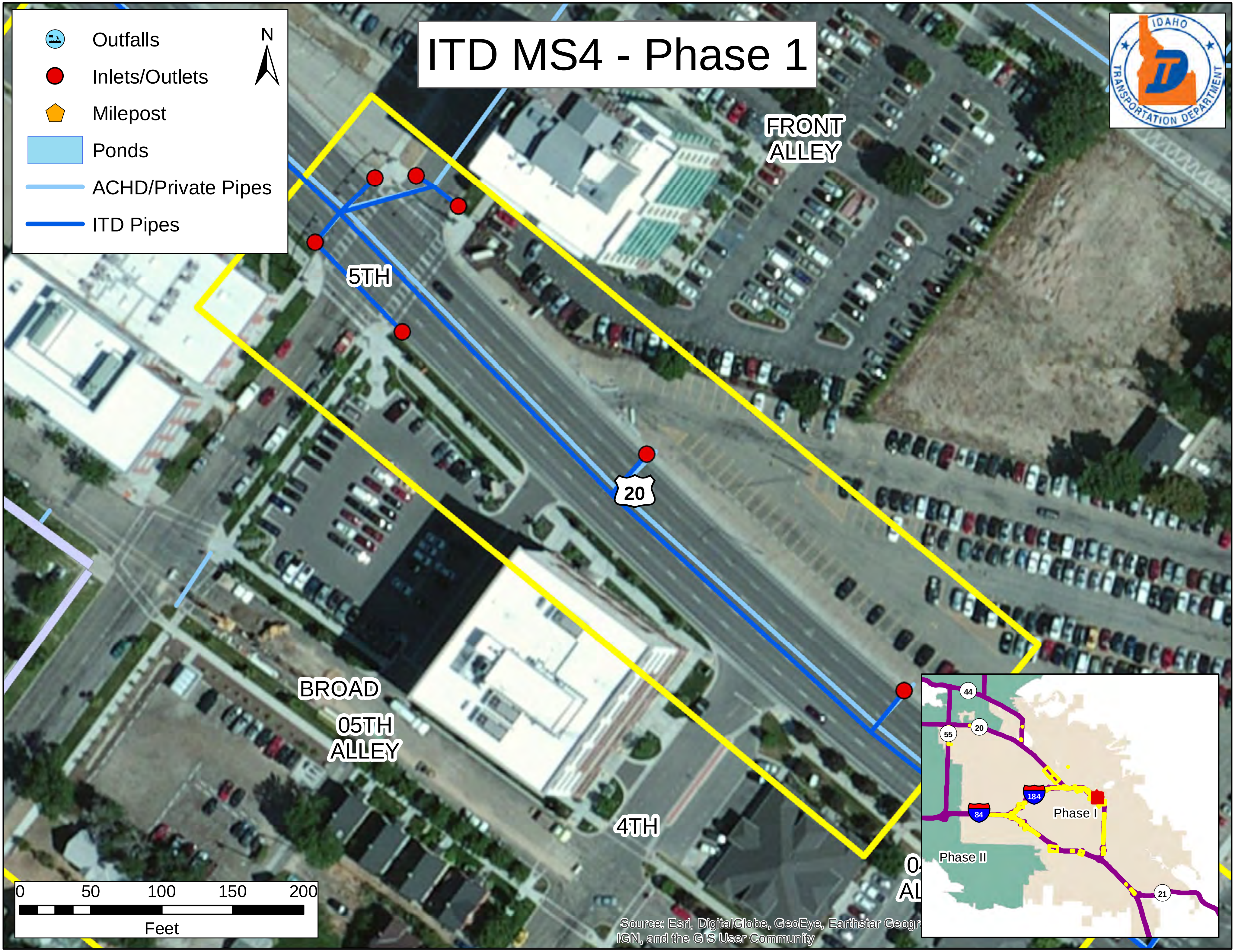
Datum: NAD83

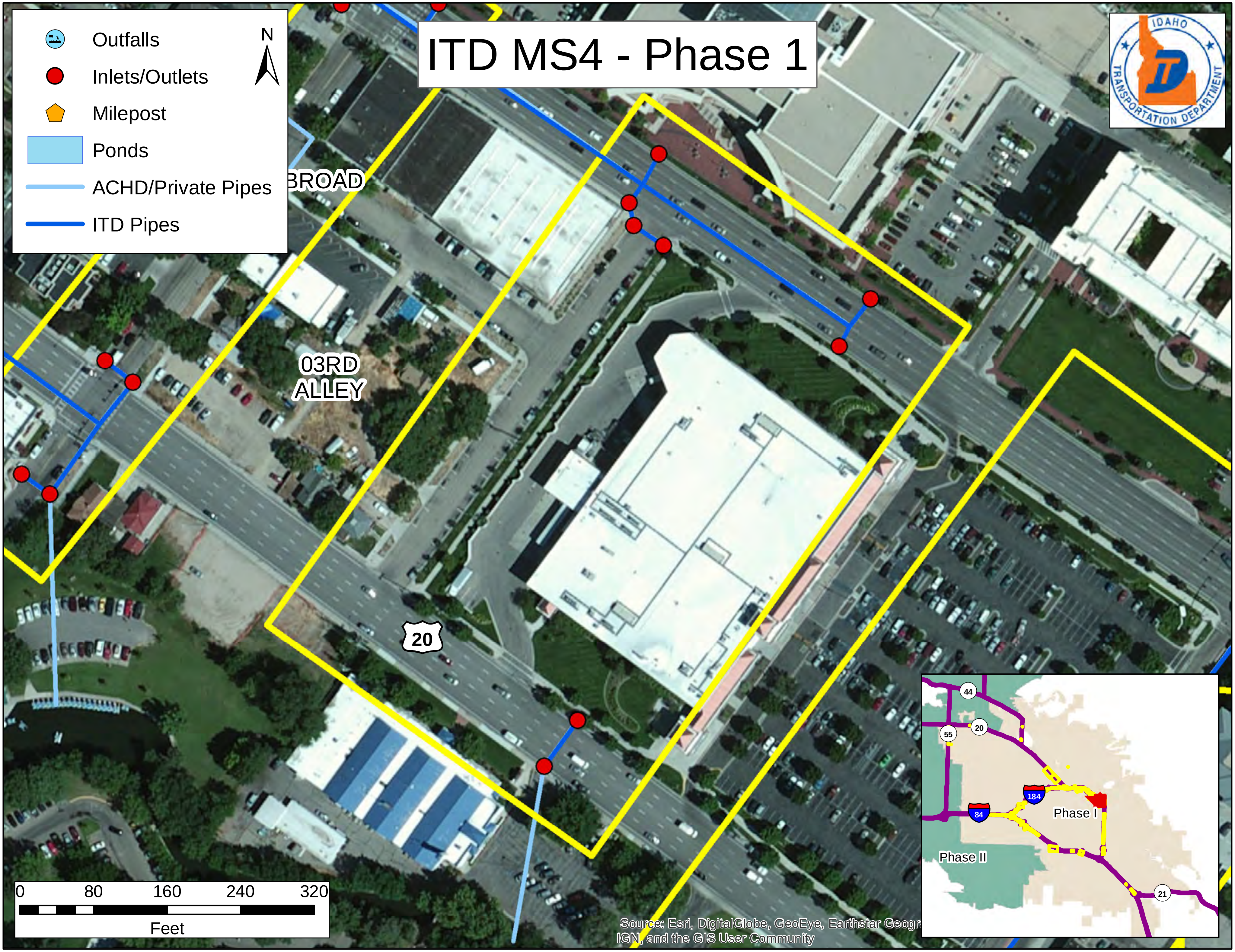

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
6TH
06TH ALLEY
BROAD
5TH
05TH ALLEY
4TH
20
0 70 140 210 280
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
4TH
04TH ALLEY
BROAD
3RD
20
03RD ALLEY
0 75 150 225 300
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
FRONT
ALLEY
5TH
20
BROAD
05TH
ALLEY
4TH
0
50
100
150
200
Feet
44
55
20
184
84
Phase I
Phase II
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
BROAD
03RD
ALLEY
20
0
80
160
240
320
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
IDAHO
TRANSPORTATION DEPARTMENT
44
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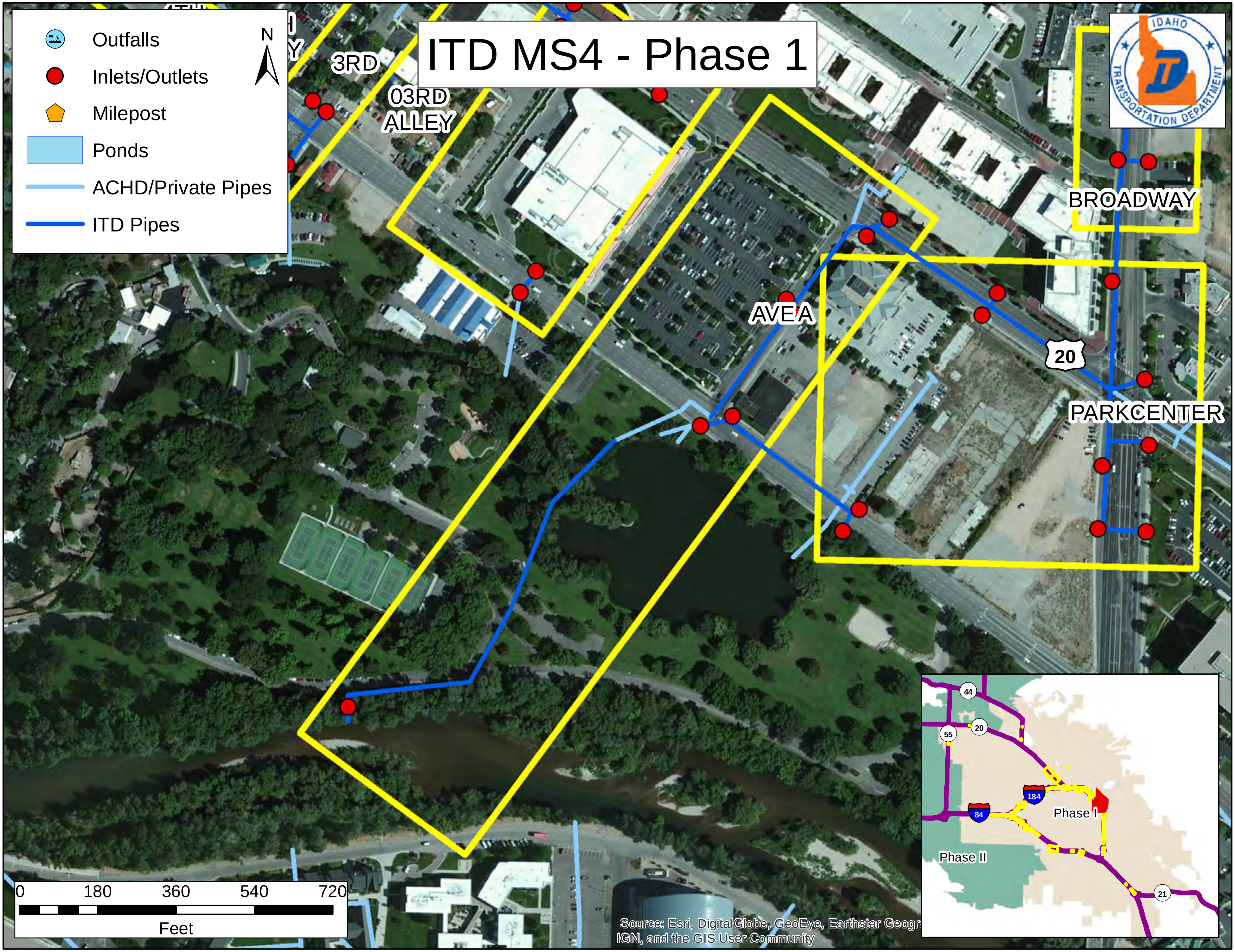
184
84
Phase I
Phase II
21

Datum: NAD83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Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
3RD
03RD
ALLEY
AVE A
BROADWAY
PARKCENTER
20
IDAHO
TRANSPORTATION DEPARTMENT
0
180
360
540
720
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
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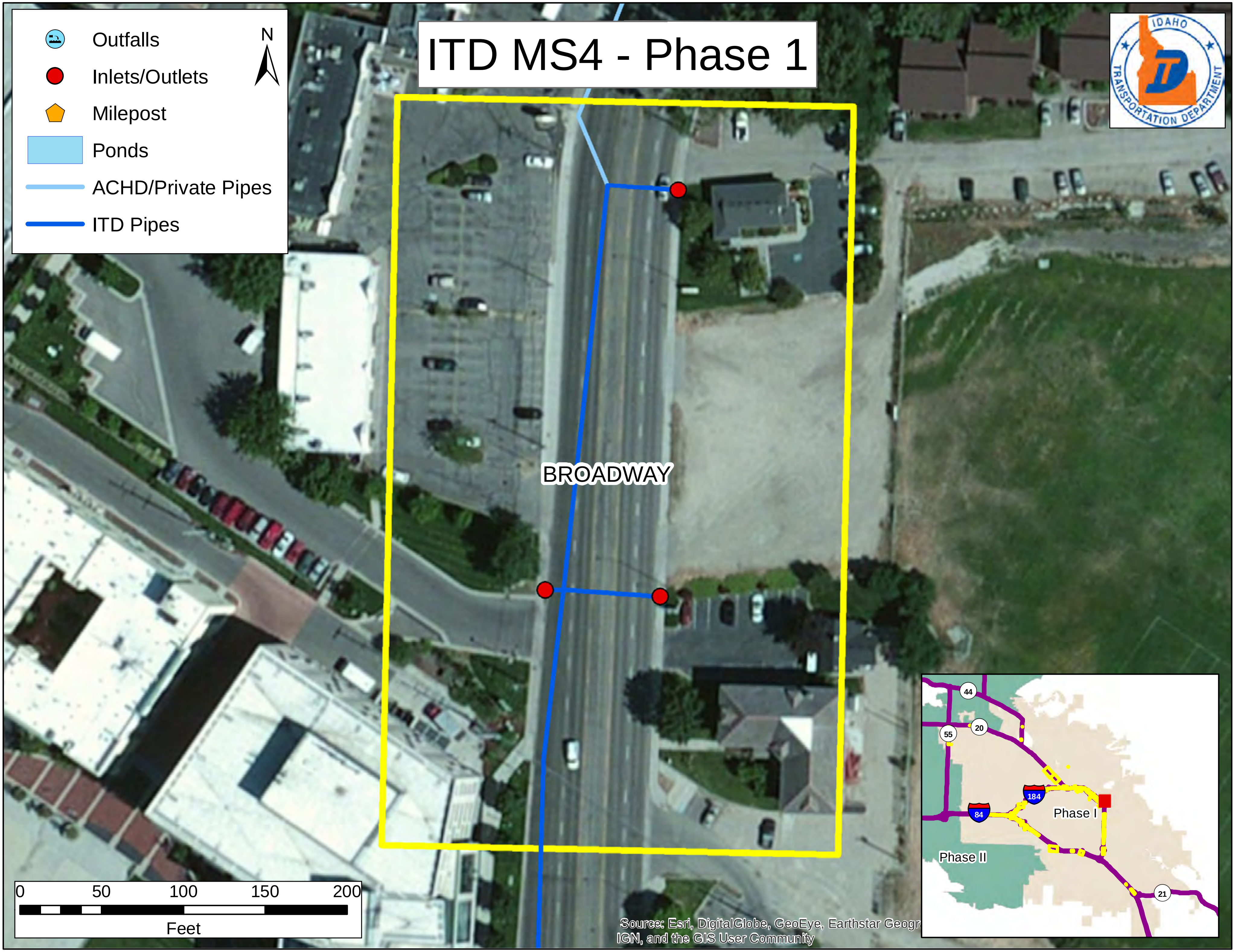
55
184
84
Phase I
Phase II
21

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
BROADWAY
0 50 100 150 200
Feet
Phase I
Phase II
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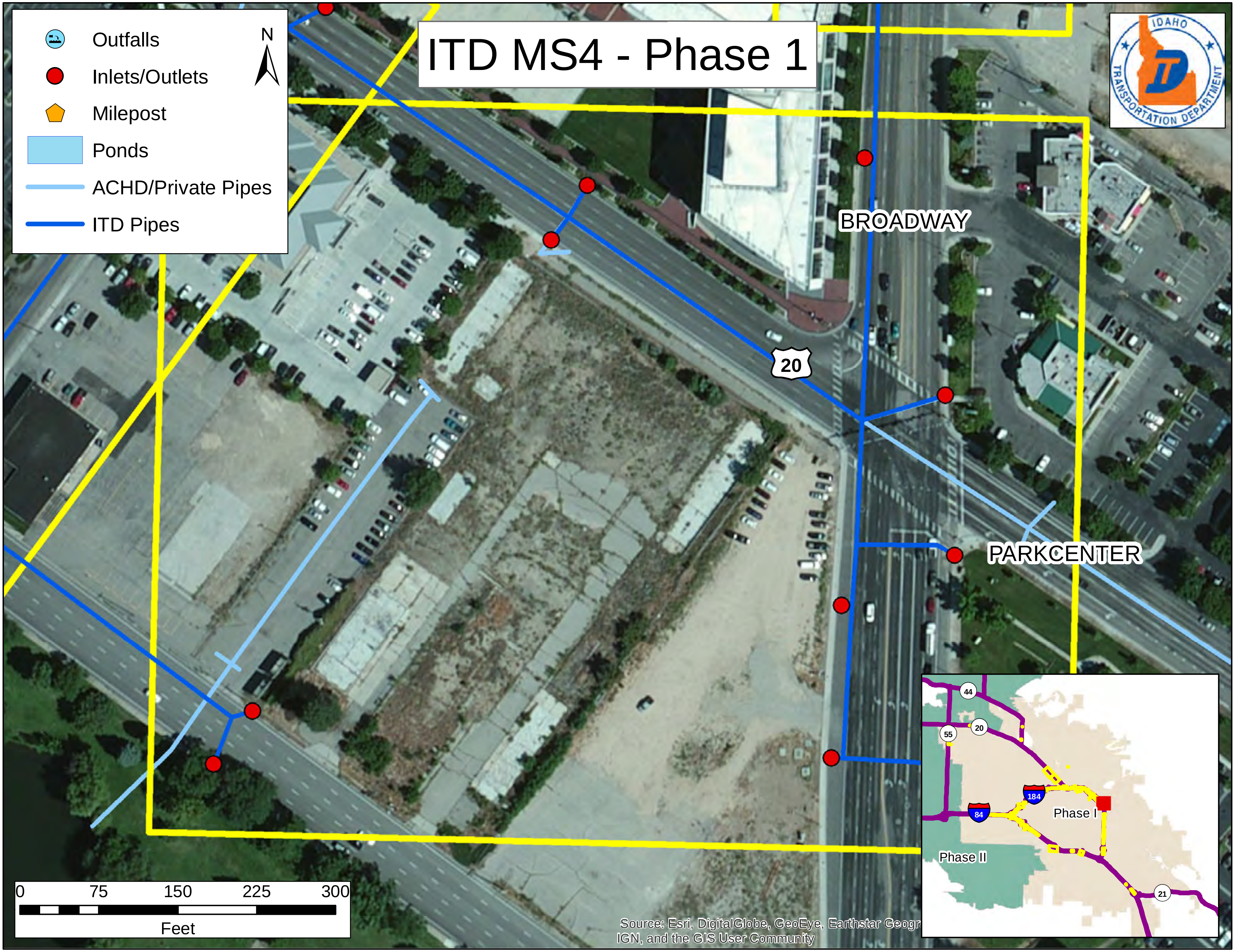
184
84
21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
BROADWAY
PARKCENTER
20
0
75
150
225
300
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
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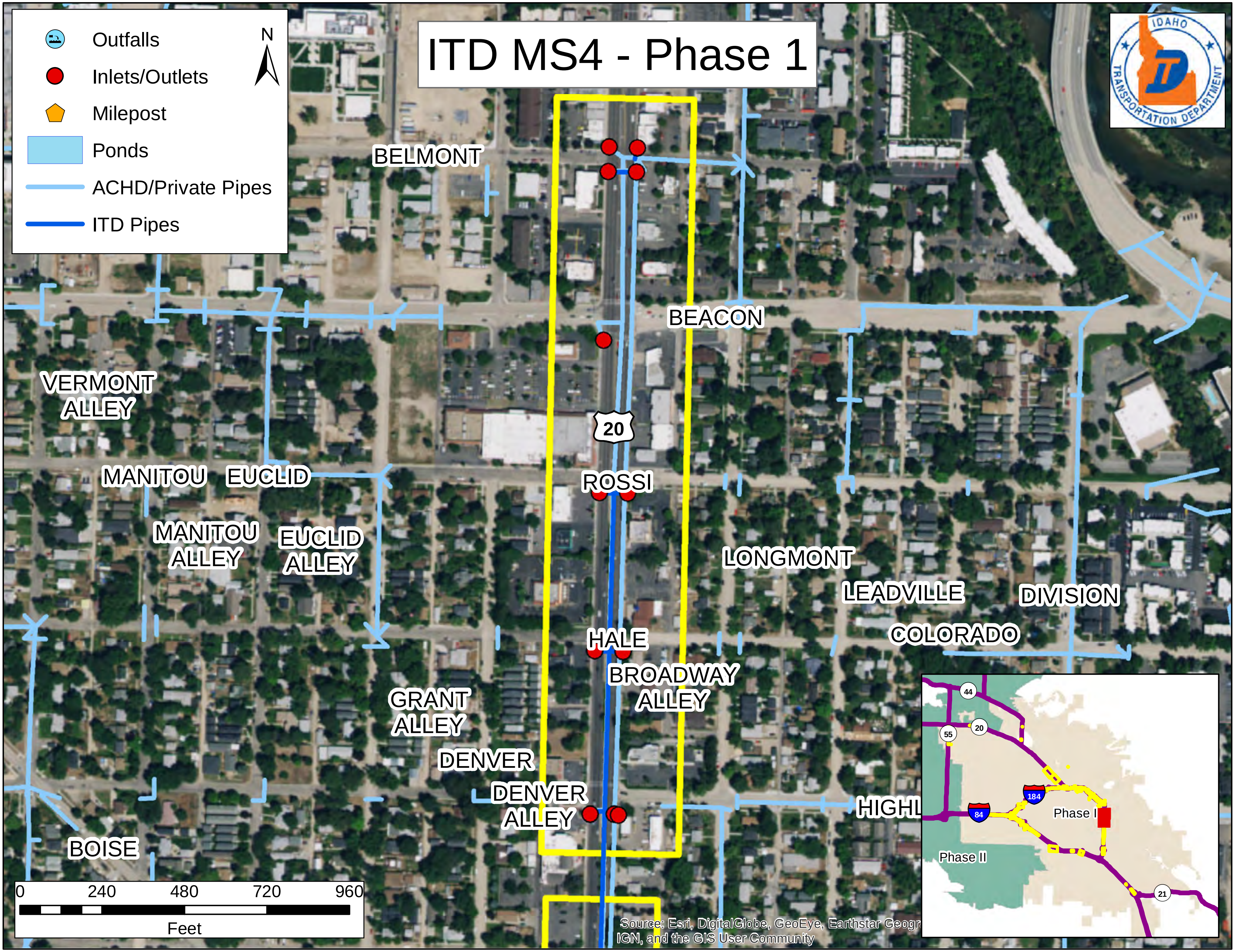
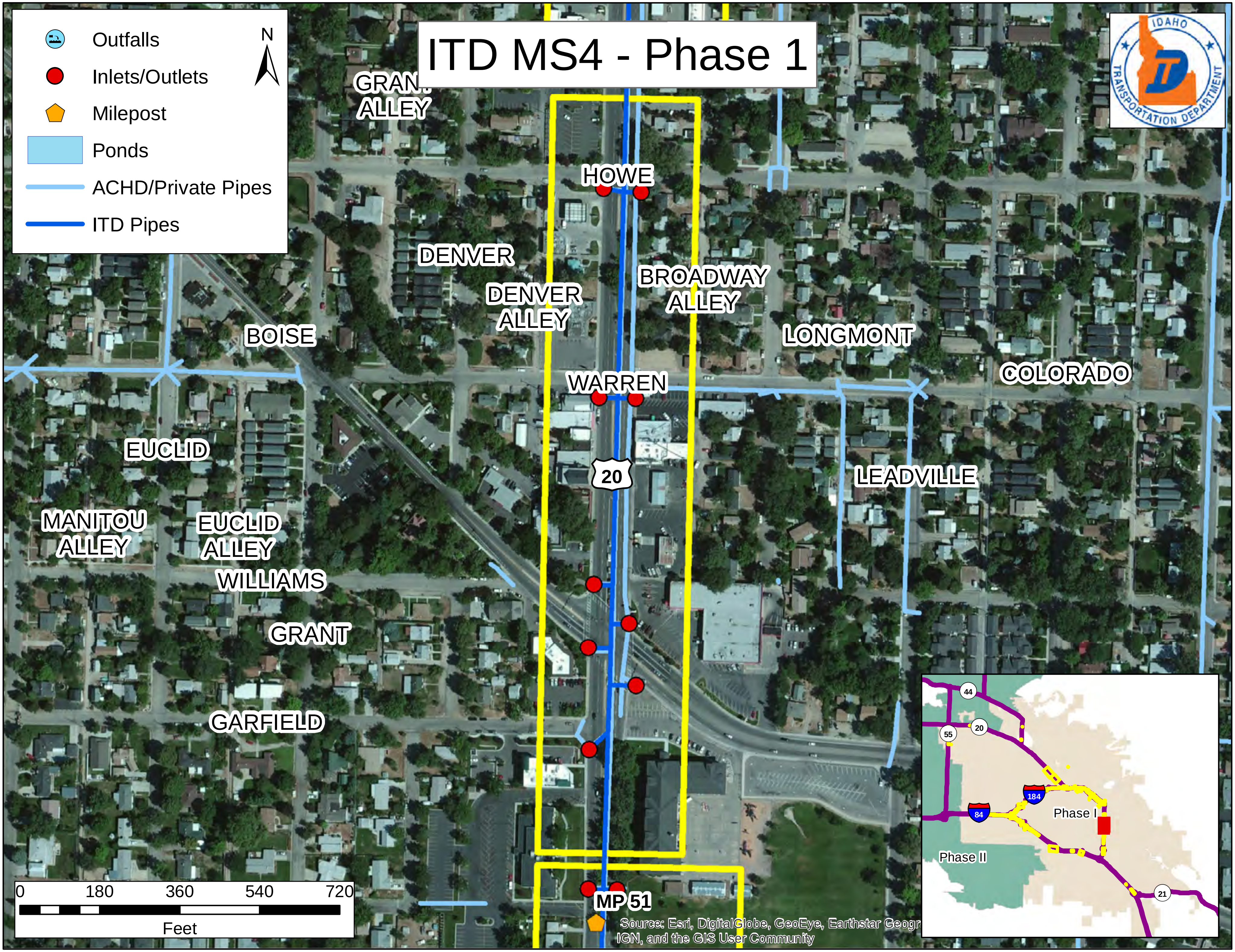
184
84
21
Phase I
Phase II

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
BELMONT
BEACON
VERMONT ALLEY
20
MANITOU
EUCLID
ROSSI
MANITOU ALLEY
EUCLID ALLEY
LONGMONT
LEADVILLE
DIVISION
COLORADO
HALE
BROADWAY ALLEY
GRANT ALLEY
DENVER
DENVER ALLEY
HIGHL
BOISE
0 240 480 720 960
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
20
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
HOWE
DENVER
DENVER ALLEY
BROADWAY ALLEY
BOISE
LONGMONT
COLORADO
WARREN
EUCLID
20
LEADVILLE
MANITOU ALLEY
EUCLID ALLEY
WILLIAMS
GRANT
GARFIELD
MP 51
0
180
360
540
720
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
55
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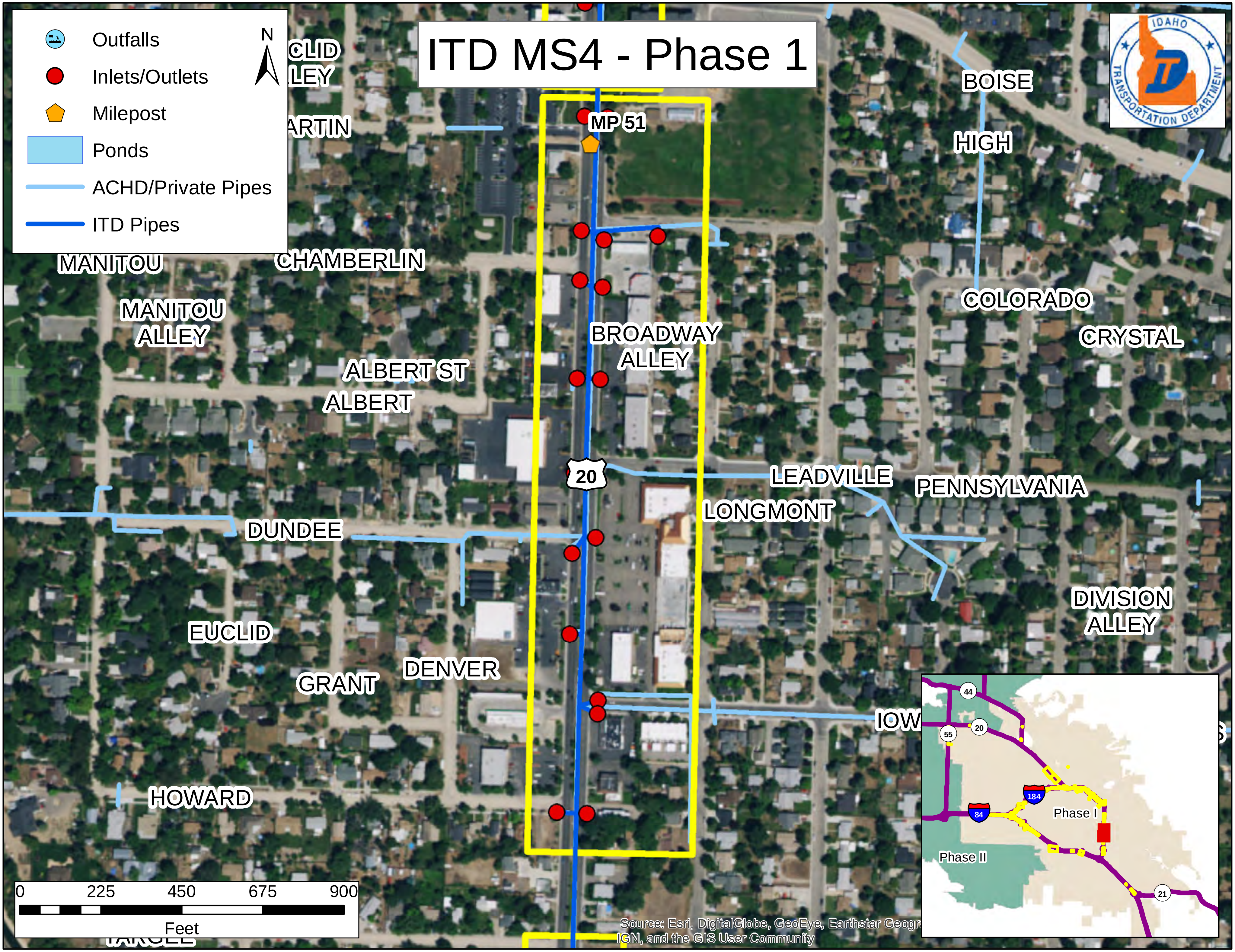
184
84
Phase I
Phase II
21
Datum: NAD83

ITD MS4 - Phase 1



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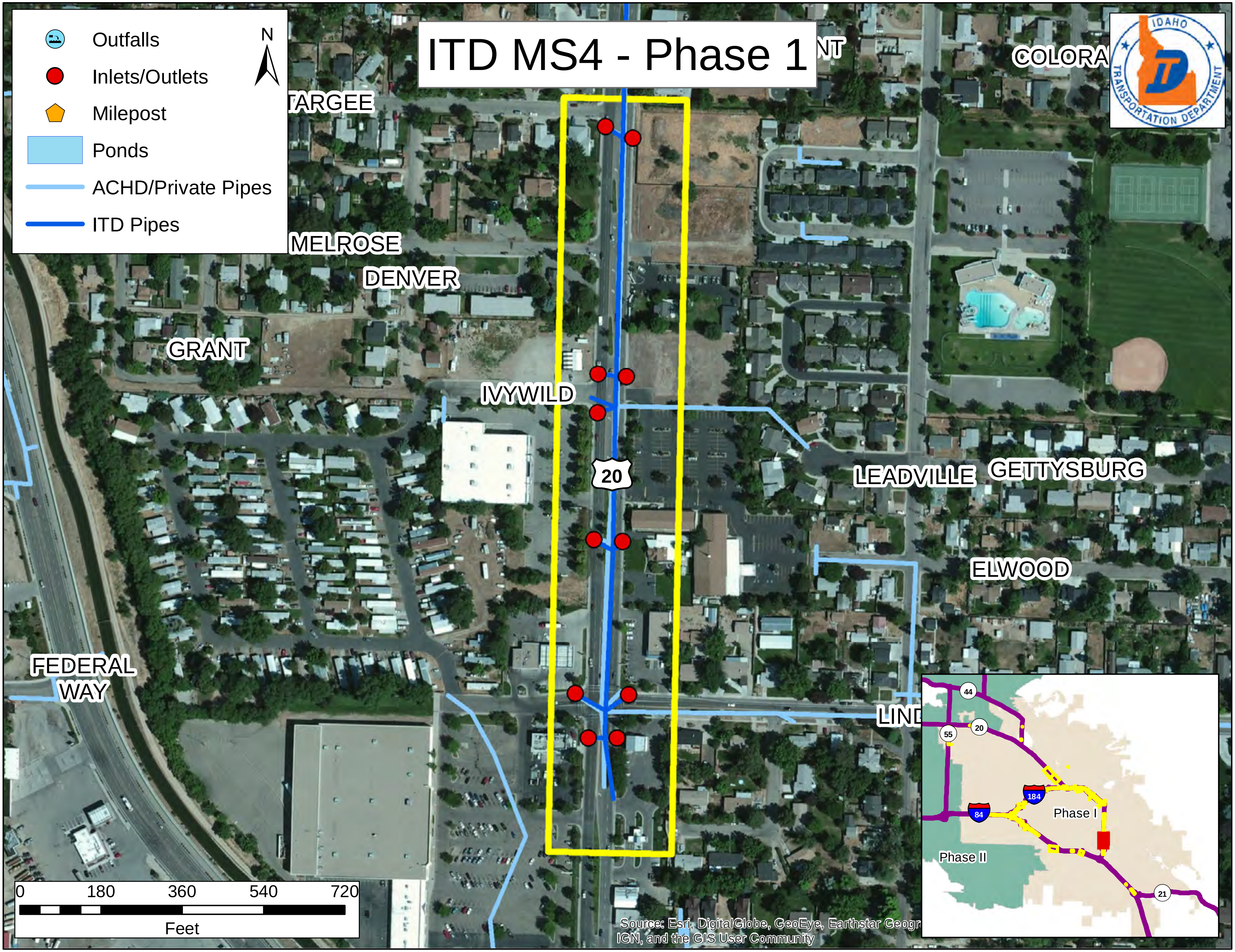
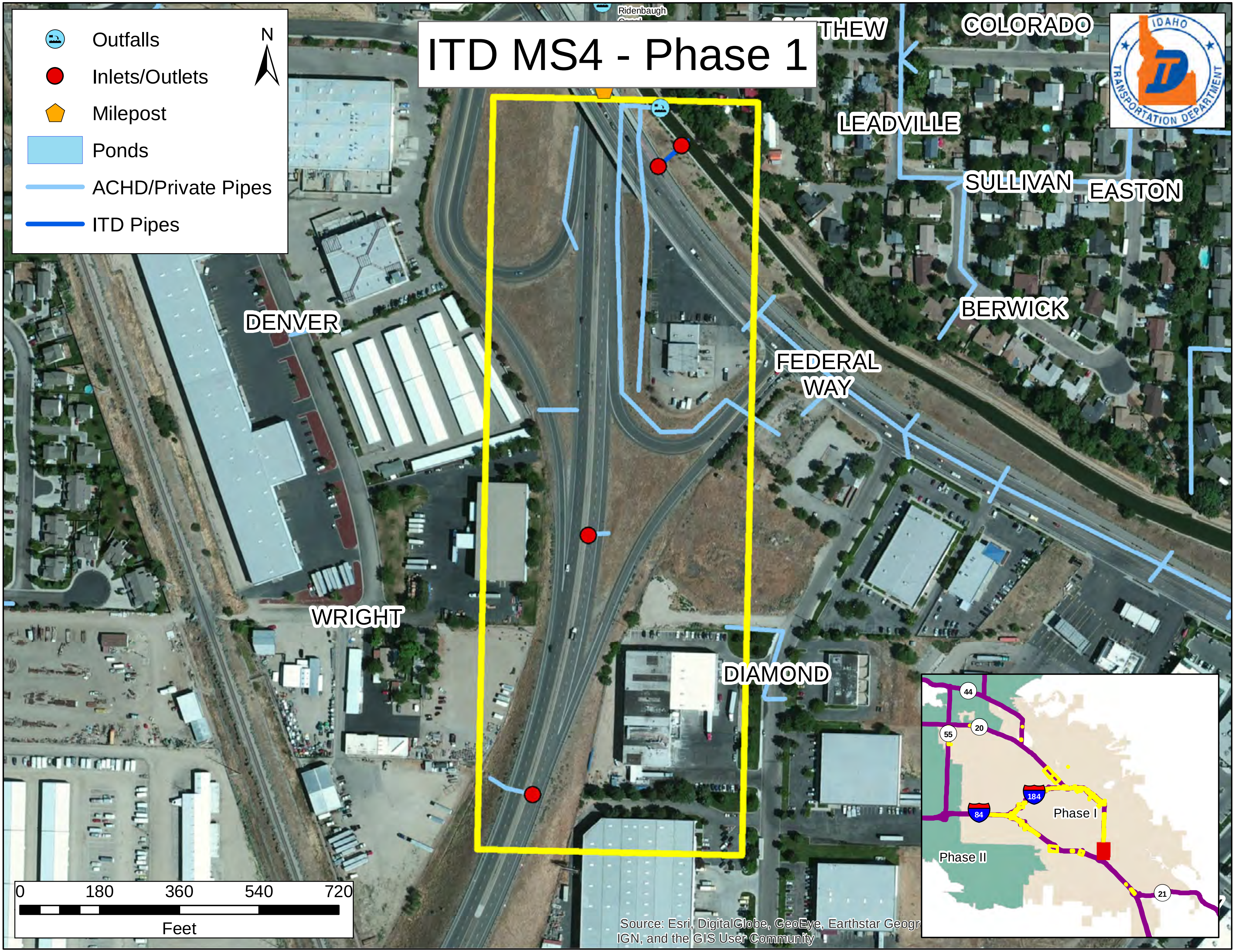

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
TARGEE
MELROSE
DENVER
GRANT
IVYWILD
20
LEADVILLE
GETTYSBURG
ELWOOD
FEDERAL WAY
COLORA
IDAHO TRANSPORTATION DEPARTMENT
44
20
55
184
84
Phase I
Phase II
21
0
180
360
540
720
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
COLORADO
THEW
LEADVILLE
SULLIVAN
EASTON
BERWICK
DENVER
FEDERAL
WAY
WRIGHT
DIAMOND
Ridenbaugh
0
180
360
540
720
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Phase I
Phase II
44
20
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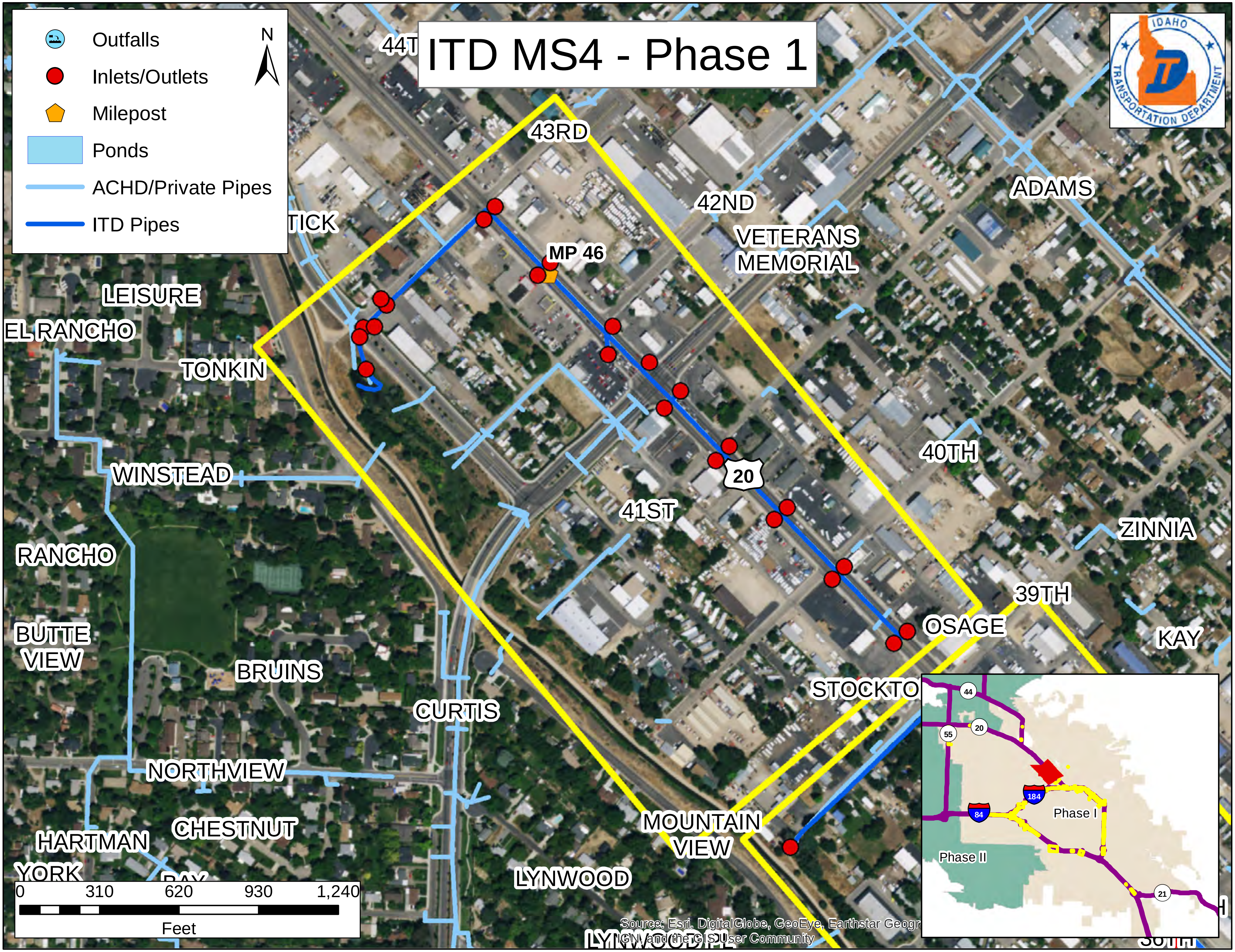
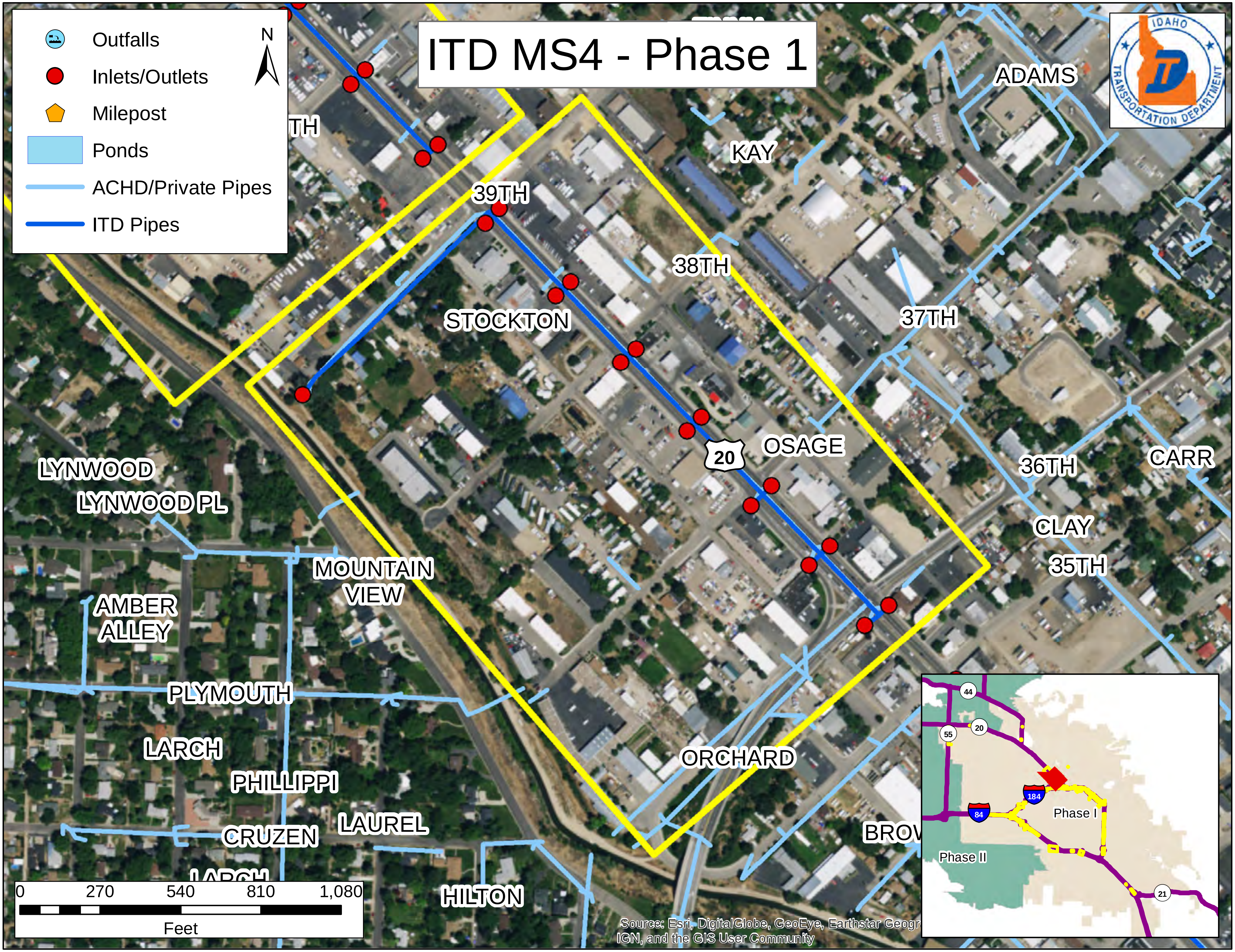
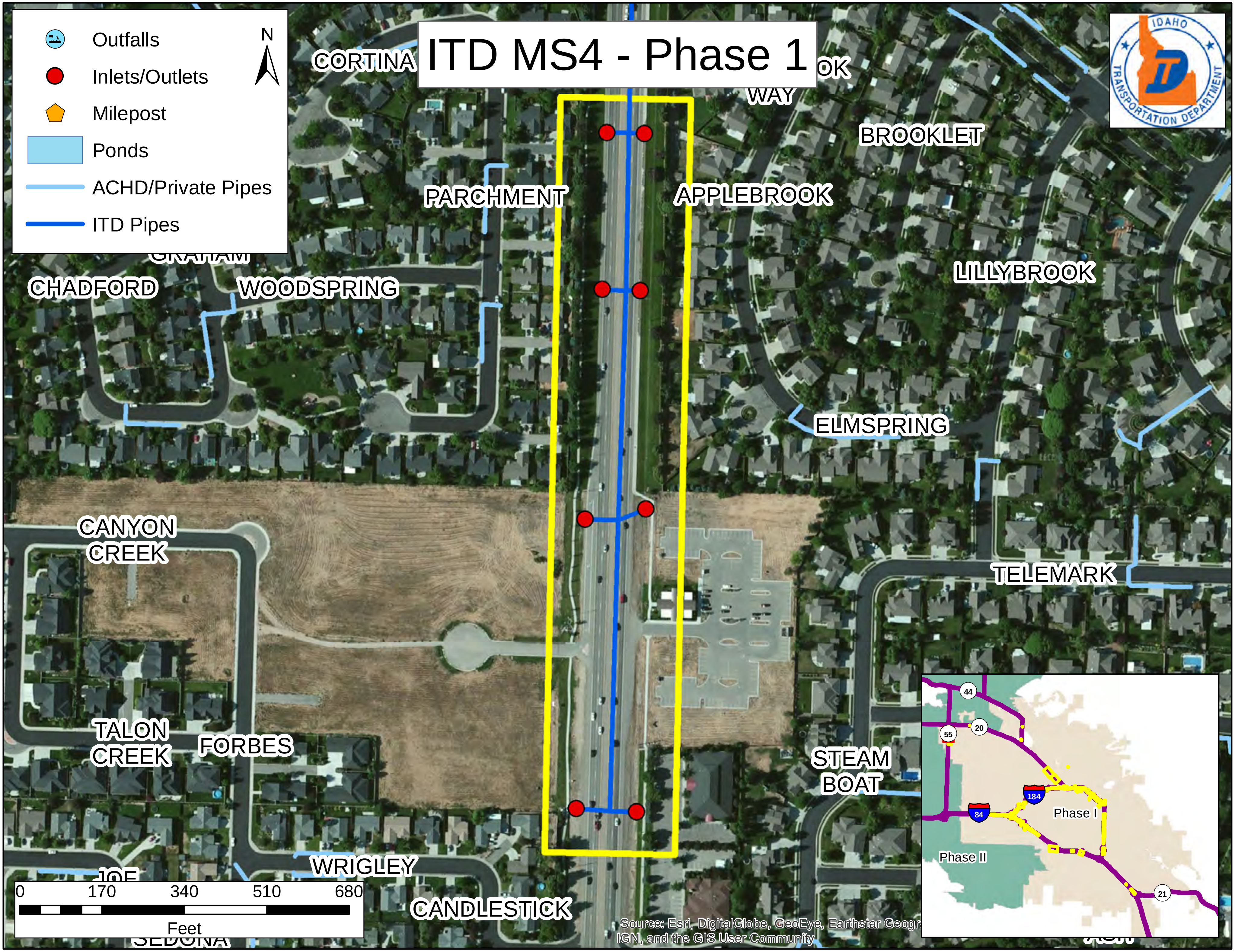
184
84
21

Datum: NAD83

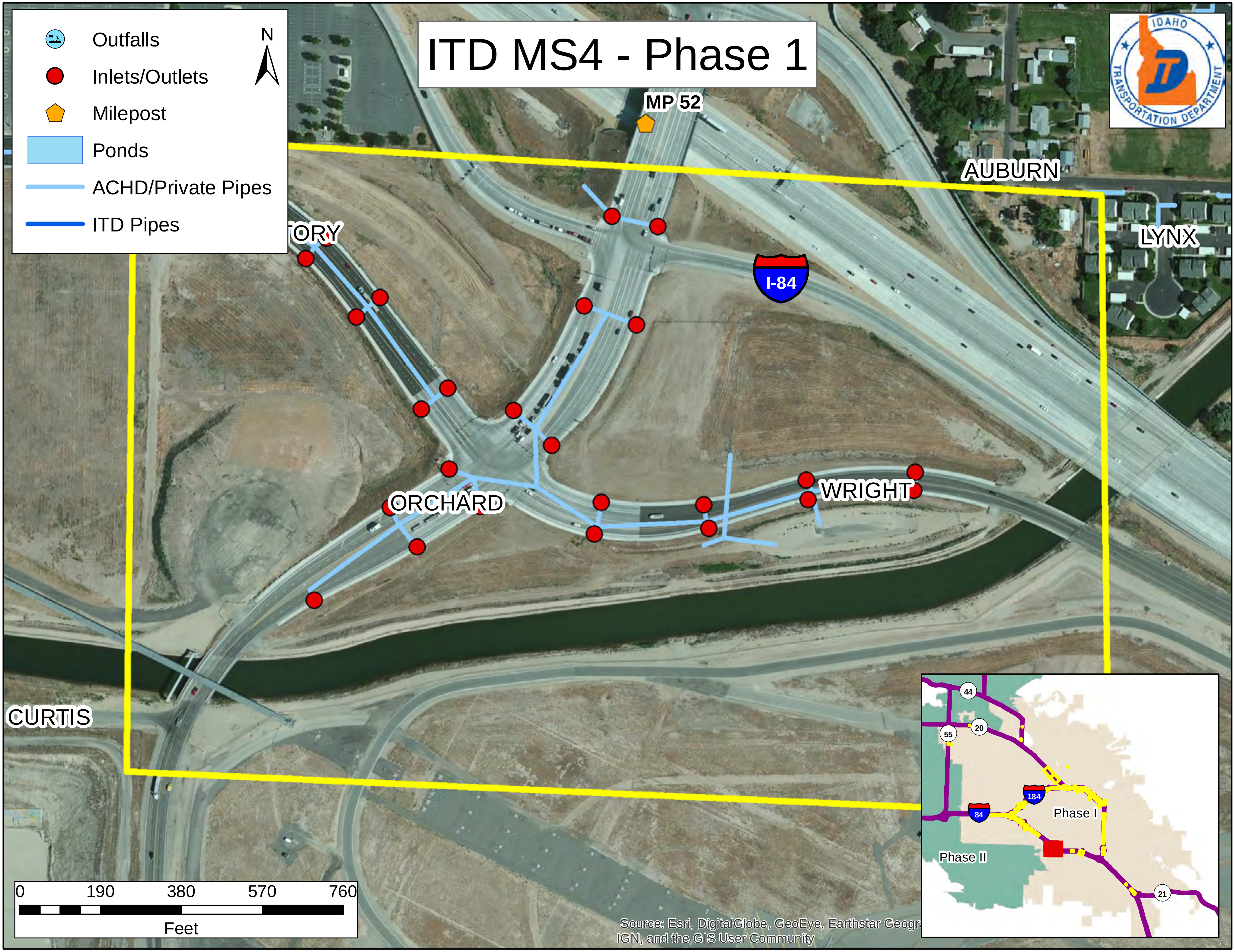

ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
44T
43RD
42ND
ADAMS
TICK
VETERANS
MEMORIAL
MP 46
LEISURE
EL RANCHO
TONKIN
40TH
WINSTEAD
20
41ST
ZINNIA
RANCHO
39TH
OSAGE
KAY
BUTTE
VIEW
BRUINS
STOCKTO
CURTIS
NORTHVIEW
CHESTNUT
MOUNTAIN
VIEW
HARTMAN
YORK
LYNWOOD
0
310
620
930
1,240
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO TRANSPORTATION DEPARTMENT
ADAMS
KAY
39TH
38TH
37TH
STOCKTON
OSAGE
20
36TH
CARR
CLAY
35TH
LYNWOOD
LYNWOOD PL
MOUNTAIN VIEW
AMBER ALLEY
PLYMOUTH
LARCH
PHILLIPPI
LAUREL
CRUZEN
ORCHARD
HILTON
0
270
540
810
1,080
Feet
44
20
55
184
84
21
Phase I
Phase II
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
Datum: NAD83


ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
IDAHO
TRANSPORTATION DEPARTMENT
CORTINA
WAY
BROOKLET
PARCHMENT
APPLEBROOK
CHADFORD
WOODSPRING
LILLYBROOK
ELMSPRING
CANYON CREEK
TELEMARK
TALON CREEK
FORBES
STEAM BOAT
WRIGLEY
CANDLESTICK
0 170 340 510 680
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geogr
IGN, and the GIS User Community
44
20
55
184
84
Phase I
Phase II
21

Datum: NAD83



ITD MS4 - Phase 1
Outfalls
Inlets/Outlets
Milepost
Ponds
ACHD/Private Pipes
ITD Pipes
N
MP 52
AUBURN
LYNX
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ORCHARD
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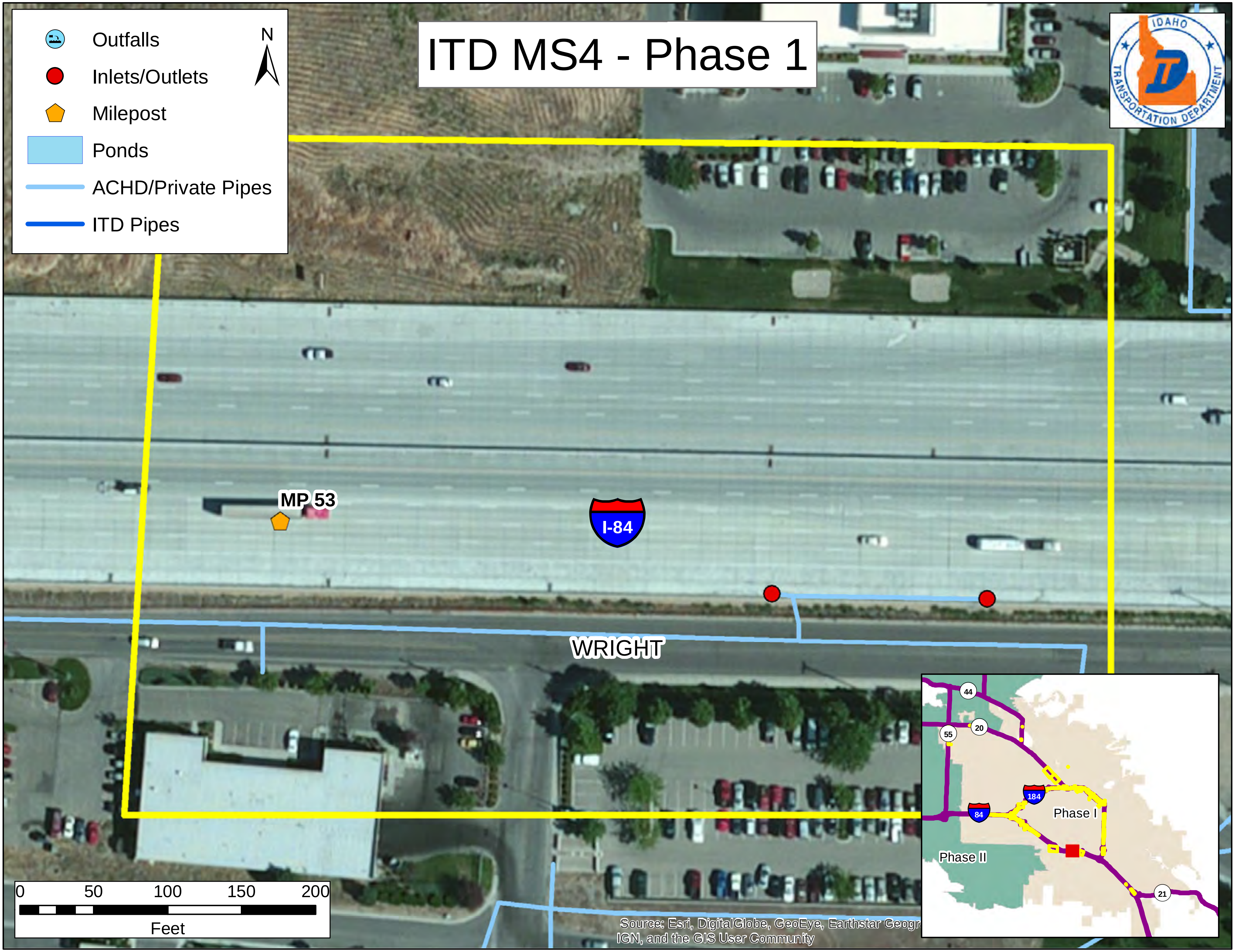
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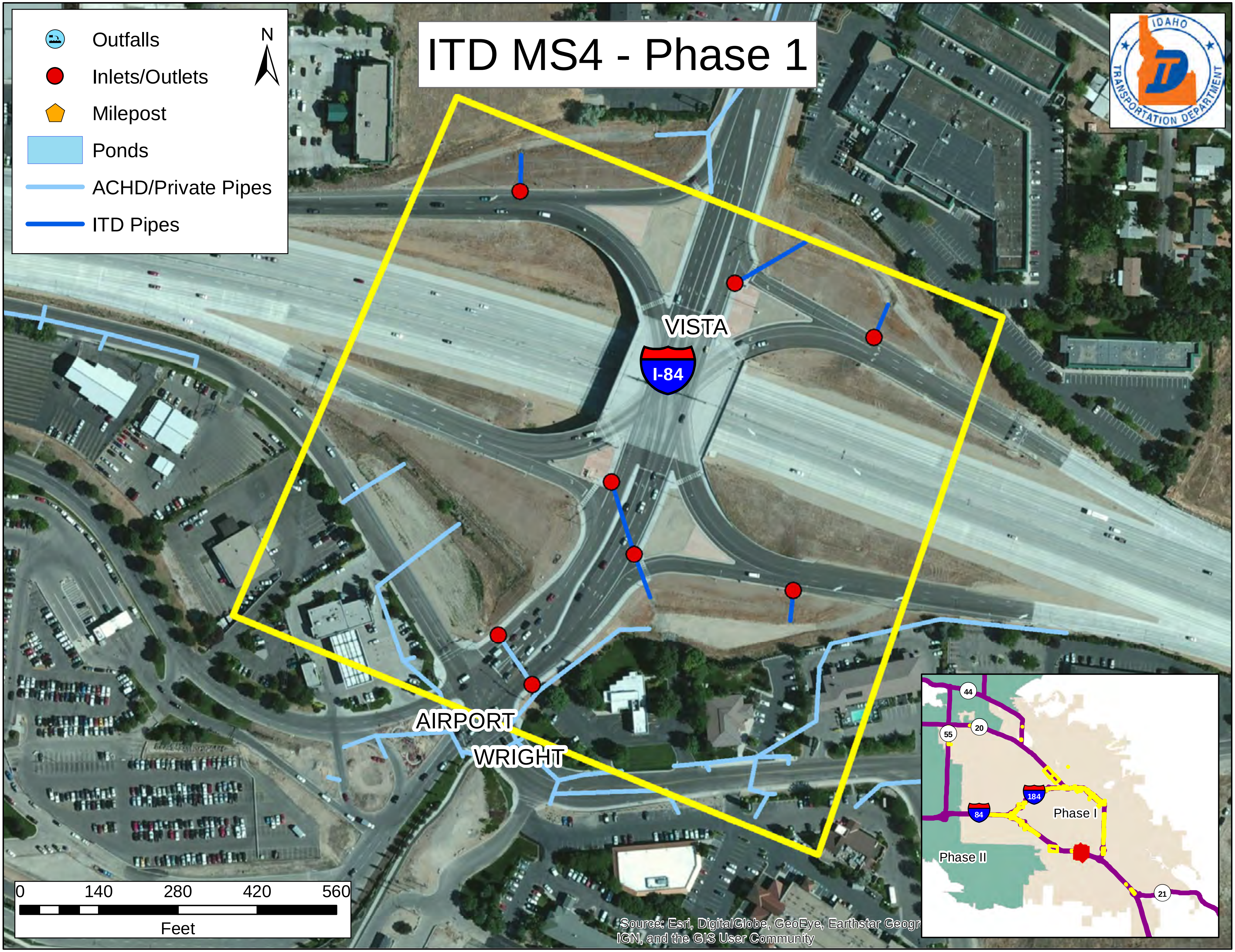

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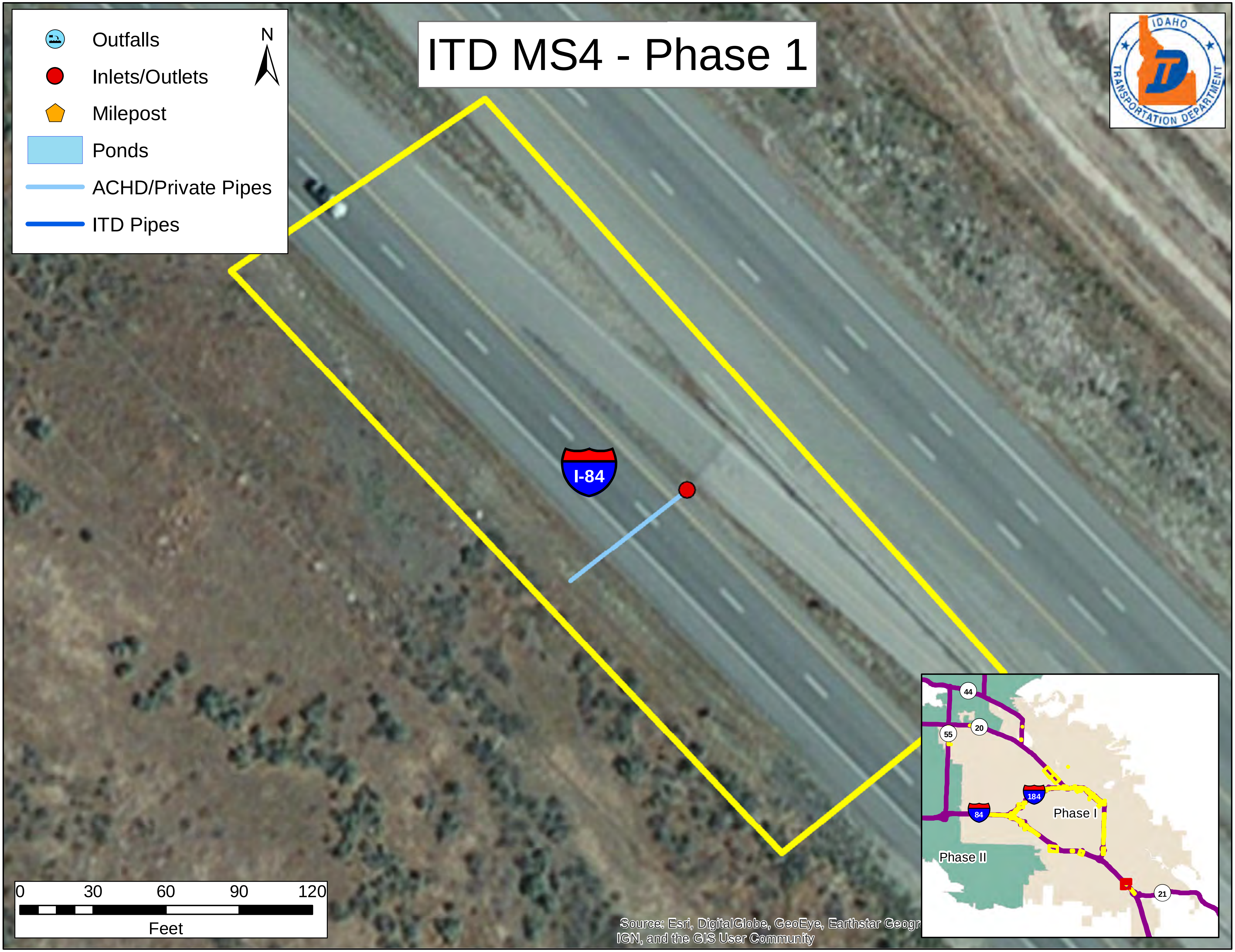

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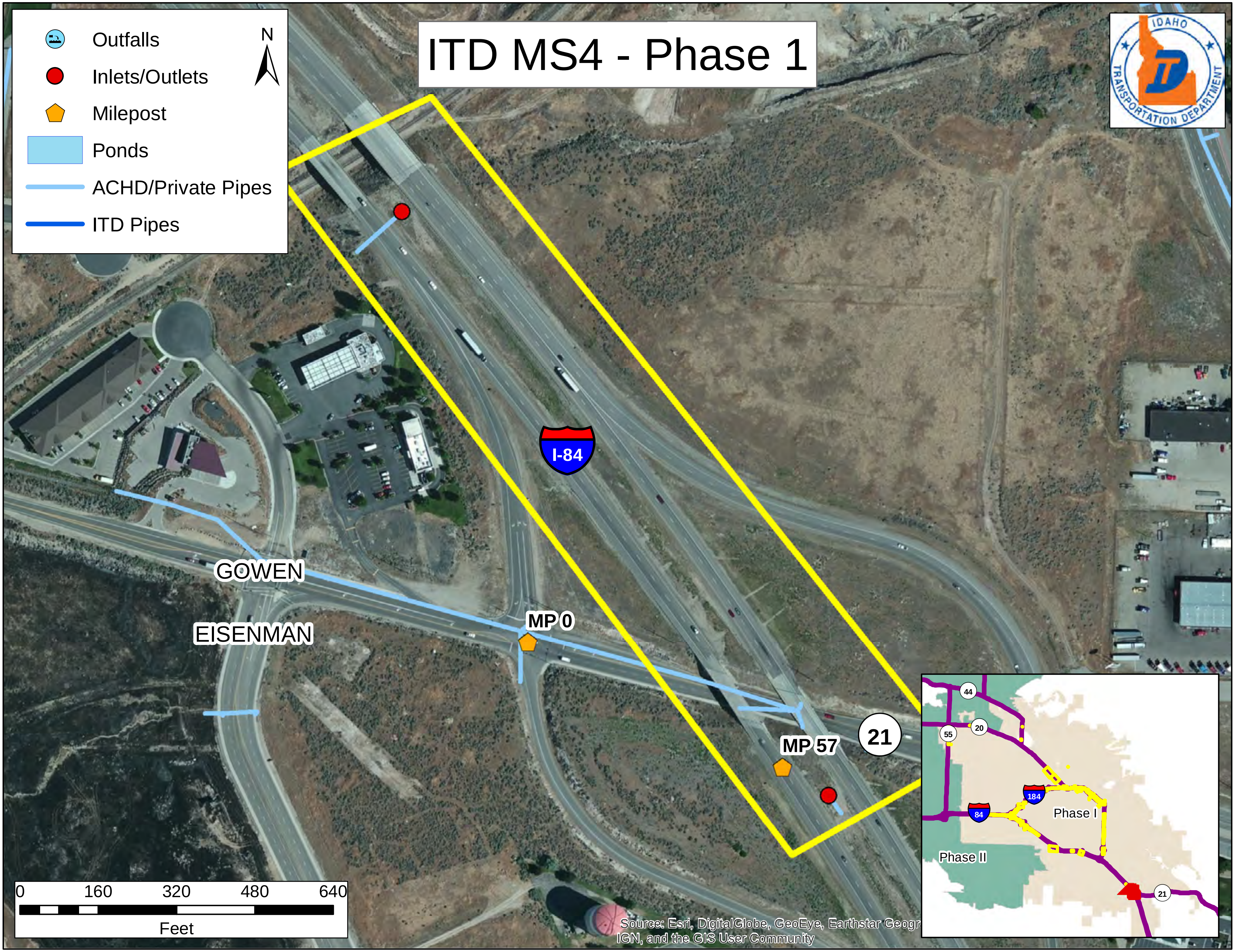

ITD MS4 - Phase 1
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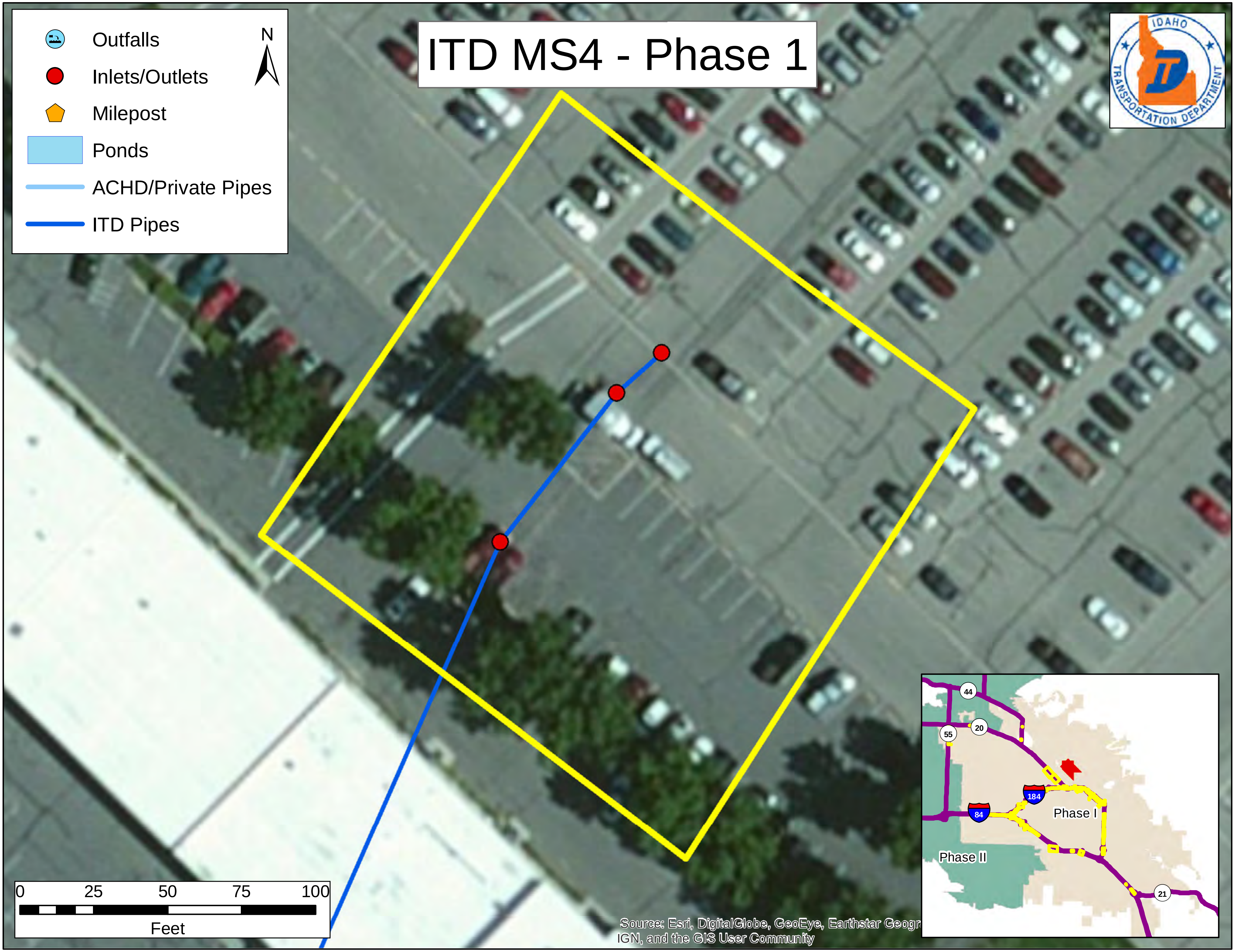

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Datum: NAD83

Supplemental Reapplication Materials

Effectiveness Evaluations – Nonstructural Controls

Permit Required Effectiveness Evaluations—Nonstructural Controls

Prepared for

Ada County Highway District

Boise, Idaho

September 30, 2017

Permit Required Effectiveness Evaluations—Nonstructural Controls

Prepared for

Ada County Highway District

Boise, Idaho

September 30, 2017

Brown AND Caldwell

950 West Bannock Street, Suite 350
Boise, ID 83702
Phone: 208.389.7700
Fax: 208.389.7750

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Section 1

Introduction and Background

The Ada County Highway District (ACHD) has evaluated structural stormwater control practices under the current and previous National Pollutant Discharge Elimination System (NPDES) Phase I permits to determine whether the control is effectively treating or preventing the discharge of one or more of the pollutants of concern into receiving waters. ACHD has now evaluated quantitative pollutant load reduction potential for sand and grease traps, hydrodynamic separators, bioretention systems, seepage beds, and vegetated swales. ACHD has also observationally evaluated permeable pavement and tree cell Green Stormwater Infrastructure solutions. To date, ACHD has conducted in-depth evaluations of 7 of the 10 major categories of best management practice (BMP) categories included in the ACHD stormwater design manual.

These structural control effectiveness evaluations have provided information on the existing design standards and use of these systems within the Municipal Separate Storm Sewer System (MS4). Quantitative evaluations, based on monitoring results and modelled predictions, have provided results of varying utility in estimating the pollutant loading reductions achievable with these structural controls in the Boise and Garden City urbanized areas (Phase I Permit Area). However, additional pollutant load reductions achievable using structural stormwater control practices are most often limited to new development and redevelopment projects. Additionally, effectiveness evaluations resulting in changes to design guidance can take multiple years from the evaluation result to redesigning and incorporating into design manuals, site development plans, and finally, the first installation of the redesigned control.

Nonstructural stormwater control practices have not been quantitatively evaluated to determine effectiveness in reducing discharges of pollutants, and no pollutant reduction credit system has been established in Idaho for determining expected reductions associated with various types of nonstructural controls. ACHD and the other permittees included in NPDES Phase I Permit Number IDS-027561 (Permit) reapplied for NPDES Phase I permit coverage in July 2017. In the reapplication package ACHD requested flexibility in the new permit language to allow for pollutant reduction effectiveness evaluations of a wide variety of BMPs implemented throughout the MS4, and not just structural stormwater control practices. This report provides an overview of methods for evaluating nonstructural controls effectiveness as evidence of proven evaluation approaches that ACHD can glean from and build upon to conduct evaluations of the nonstructural control practices occurring in the Phase I Permit Area.

Section 2

Effectiveness Evaluation Reviews

ACHD uses several nonstructural stormwater control practices to minimize the amount of pollution discharged to receiving waters from the MS4. Previous evaluations of effectiveness have focused on the pollutant removal capabilities of structural controls that are included in ACHD's stormwater design manual, in accordance with Permit requirements. This section provides supporting evidence to show that evaluating nonstructural controls could reasonably be expected to provide results and guidance the same or better than evaluating only structural stormwater control practices.

The three BMPs outlined below are examples of nonstructural controls that ACHD has implemented throughout the Phase I Permit Area. Literature supporting quantitative evaluation of pollutant loading reductions comes from across the country from a variety of programs. Under the next Phase I permit, one or more of these approaches could be adapted to provide an evaluation that is representative of the implementation approach and environmental and climate conditions in the Boise area. The results of such an evaluation would then be used to inform decisions about stormwater management, apply a more appropriate annual pollutant load reduction estimate, and guide prioritization of those portions of the MS4 where additional controls can be accomplished and current practices can be adjusted to decrease discharges of pollutants to receiving waters.

2.1 Leaf Pickup

Fallen leaves are a documented source of phosphorus and nitrogen in stormwater runoff (Selbig, 2016). When fallen leaves are exposed to stormwater runoff the stormwater leaches out nutrients and other compounds from the leaf. Leaves that have collected in gutters, structural controls, and drop inlets continue to export phosphorus throughout the season. ACHD currently conducts leaf pickup activities across many parts of the Phase I Permit Area with a focus on neighborhoods with a high density of mature landscaping. As the literature shows, the amount of leaves picked up can be translated into a phosphorus load reduction.

2.1.1 Overview of Methods

Regulatory and research agencies have recently evaluated the benefits of leaf pickup for controlling phosphorus. These studies have shown a significant water quality benefit when timely leaf pickup activities are prioritized in areas with dense canopy cover.

A study conducted by the United States Geological Survey (USGS) (Selbig, 2016), used a paired basin approach to monitor stormwater runoff quality for nitrogen and phosphorus in two small residential watersheds in Wisconsin. The watersheds included in this study were selected based on proximity to one another, accessible monitoring points, and comparable density of canopy cover over roadways. No autumn leaf pickup activities were conducted in the control watershed, while leaf pickup and sweeping was conducted at least weekly during the months of October and November in the test watershed. When necessary, crews were deployed to collect leaves from the street between weekly scheduled collections to simulate a "best-case scenario" for municipal operations. Flow weighted composite samples were collected and analyzed to obtain an event mean concentration for each watershed during each monitored rainfall event.

A total of 71 paired samples were collected over a 3-year study period. Both watersheds were managed the same way for an extended calibration phase to ensure comparability between the two watersheds. Forty samples were collected during the calibration phase and the remaining 31 samples were collected under test conditions. Results of the paired monitoring showed significant reductions (up to 80 percent) in total and dissolved phosphorus during the autumn season. Leaf pickup had no impact on dissolved nitrogen but did decrease total nitrogen by approximately 20 percent.

The 2017 Massachusetts Small MS4s General Permit describes a pollutant reduction credit system for leaf pickup in the autumn season. Available credit for Massachusetts permittees is a function of the phosphorus export coefficient (source load) per land use type, frequency of pickup, impervious surface acreage in the collection area, and a set phosphorus reduction factor. The permit does not cite a source for the phosphorus reduction factor, and it is unclear whether the reduction factor used is transferrable between geographies or if it may be necessary to determine a reduction factor specific to the local climate and dendrology of the Phase I Permit Area.

2.1.2 Implications for ACHD Activities

Various leaf pickup alternatives can be evaluated using the Massachusetts credit formula to analyze the impact of focusing leaf pickup activities in different land uses and at varying frequencies. As the USGS study points out, frequency of pickup is a key component in pollution reduction potential. The longer leaves are on the ground, the more opportunity there is for phosphorus to be leached out of the leaf. The results of the USGS study represent a level of collection frequency that may not be realistic for leaf pickup operations in most areas. However, the study illustrated a significant reduction in nutrient loads associated with leaf pickup. Leaf collection practices employed by ACHD are likely having an unmeasured and uncredited positive impact on nutrient loads discharged to receiving waters.

2.2 Catch Basin Cleaning

Catch basin cleaning is a common practice in most urban watersheds in the United States. Several entities have worked to derive expected pollutant reduction benefits associated with retaining and then collecting material that has been mobilized in stormwater runoff at the drop inlet before it travels down the storm drain pipe. ACHD currently conducts catch basin inspections at an assigned frequency of no less than every 2 years as stated in Permit Part II.B.4.b. Under the Permit, ACHD is required to follow up on inspections with appropriate maintenance actions, including cleaning when necessary.

2.2.1 Overview of Methods

In 2006, the City of Portland commissioned an extensive literature review of several studies previously conducted to determine quantitative total suspended solids (TSS) removal rates achieved with catch basin cleaning (Herrera Environmental Consultants, 2006). Most studies used comparative monitoring, sampling effluent from multiple sites of both cleaned and uncleaned catch basins. One study used a model to predict TSS removal rates over range of cleaning frequencies, which matched the general distribution of monitoring results.

Multiple studies included in the review found a point of diminishing returns with increased cleaning frequency. For instance, cleaning catch basins monthly does not result in three times the pollutant reduction achieved with quarterly cleaning. However, the studies also agree that under most scenarios catch basins were no longer an effective means of reducing pollutants after approximately

12 months had passed since cleaning due to the typical capacity of the sumps. This figure can change based on the land use and roadway type.

A more recent study by the City of Portland evaluated the cost effectiveness per pound of pollutant load reduction at various frequencies in each land use type. Based on management conditions, increasing cleaning frequency of catch basins located along select arterials and major roadways was more cost effective than maintaining a target frequency on all residential roadways.

The Maryland Department of the Environment's (MDE) guidance for accounting for stormwater wasteload allocations and impervious acres treated (MDE, 2014) and the Massachusetts general permit for small MS4s use a credit system for TSS and total phosphorus (TP) reductions from catch basin cleaning. In general, credit calculations are based on impervious acreage treated, frequency of cleaning and land use, and unique percent removal assumptions published by each respective regulatory agency. The MDE also uses a published mass loading approach for practices including catch basin cleaning and street sweeping that collect debris and sediment grain sizes greater than those accounted for in TSS analyses. The mass loading approach assumes a certain percentage of the total mass of any gross material/debris is TSS and TP. The mass loading approach, therefore, applies a reduction ratio for each pollutant to a measured or estimated amount of material of larger grain sizes removed from the MS4.

2.2.2 Implications for ACHD Activities

Results of these studies can be applied to ACHD's management approach to determine the relative return on investment for maintenance actions based on land use and roadway type. An alternatives analysis can be conducted using the credit system or a combination of information from the studies to evaluate priority areas and benefits gained with varying cleaning frequencies. The studies described above indicate that a standard interval for all catch basins, as the Permit currently requires, may not provide the flexibility desired to optimize pollutant load reductions in catch basin cleaning operations.

2.3 Street Sweeping

Street sweeping schedules are described in Permit Part II.B.4.d, which also requires that ACHD estimate the effectiveness of street sweeping activities to minimize pollutant discharges to the MS4. ACHD developed a street sweeping plan in 2015 to document sweeping practices and identify specific activities and approaches that target pollutant reduction. This documentation of current practices provides a benchmark to test various alternatives.

2.3.1 Overview of Methods

There are multiple possible approaches to evaluating effectiveness of street sweeping including various types of monitoring, modeling, or gross estimation based on the amount of material collected (mass loading, as described in Section 2.2). Examples of widely used models and a brief review of selected monitoring studies showing a range of approaches are discussed below. Some studies used a combination of monitoring and modeling to evaluate effectiveness.

2.3.1.1 Monitoring

The USGS and the Center for Watershed Protection (CWP) both completed intensive studies on the effectiveness of street cleaning devices at reducing loads of TSS and TP in stormwater discharges from urbanized areas. One USGS study (Selbig and Bannerman, 2007) used a residential land use basin comparison approach to evaluate the performance of different types of sweepers in relation to a control watershed. In the test watersheds, street cleaning was conducted on a weekly basis. A vacuum was used to collect samples of street dirt before and after sweeping each week to analyze particle size distribution and calculate an estimate of the amount of street dirt and the portion that could be mobilized in stormwater. Paired stormwater runoff composite samples were collected to compare stormwater quality in the treated versus untreated watersheds.

Another USGS study (Sorensen, 2013) focused on high density and multi-family residential areas employing the same methods as the 2007 study, minus the paired basin approach. In addition to evaluating the street dirt yield, the 2013 study also conducted laboratory chemical analysis of the smaller particle sizes collected in street dirt samples, that could be mobilized in stormwater. These small particles were analyzed for total organic carbon, total metals, and TP. Monitoring data, including particle size distribution in street dirt, was used to inform a model to predict pollutant load reductions in the monitored watershed.

The CWP study (CWP, 2008) also collected street dirt and stormwater event mean concentration data for its evaluation of pollutants of concern impacted by street cleaning activities in the Chesapeake Bay watershed. The study incorporated sampling data, survey results, and published literature to develop a conceptual model for expected pollutant removal efficiencies for TP, total nitrogen, and total solids (TSS included) under various sweeping conditions.

2.3.1.2 Modelling

Based on the literature, modelling is a more cost effective and quicker method to evaluate effectiveness of street cleaning activities. Common and accessible models with street cleaning components include the Windows-based Source Loading and Management Model (WinSLAMM) for Microsoft, Simplified Particulate Transport Model, and Watershed Treatment Model. These models are in use by regulatory agencies in different parts of the country to evaluate pollutant loading reductions from all types of stormwater pollution control practices. Using physical information about the roadways in the managed area and the sweeping practices used, models predict the amount of stormwater-transportable material likely to be picked up by street sweepers.

Model scenarios can be used to analyze a variety of management alternatives to quantitatively compare the pollutant reduction benefits of each alternative. Examples of street sweeping practices that can be evaluated in the models include the following list:

- Type of sweeper used
- Frequency of sweeping activities on various types of roadways
- Occurrence of curbs and catch basins
- Smoothness of roadways
- Parking controls

2.3.2 Implications for ACHD Activities

Monitoring the quality of stormwater runoff or changes in street dirt yield alone did not result in high confidence intervals in the effectiveness evaluations reviewed. Monitoring data was most useful as a supplement to the broader range of tools (surveys, literature reviews, and modelling) to estimate effectiveness under various conditions. ACHD's street sweeping program and service area is well documented. Existing information on street surfaces, lane miles per roadway type, and sweeping frequency provides the basis to begin evaluating the effectiveness of this nonstructural control for reducing loads of pollutants of concern discharged in stormwater runoff. The factors that impact pollutant reduction potential suggest that an alternative sweeping schedule, compared to the schedule in the current Permit, could result in increased pollutant load reductions in the Phase I Permit Area.

Section 3

Conclusions

A considerable amount of research and studies have been done to determine the effectiveness of street sweeping and catch basin cleaning at reducing pollution in discharges from MS4s. The body of work around leaf pickup is not as substantial, but the information that is available suggests a significant pollutant reduction benefit under the right circumstances and management conditions.

One recurring theme in the literature is the significant commitment of time and effort required to determine the effectiveness of any given control using monitoring data alone. Many of the results of monitoring studies were inconclusive without the addition of modelled values or incorporation of conclusions from previous studies. According to the Environmental Protection Agency's (EPA's) Environmental Technology Verification Protocol (EPA, 2002) the recommended minimum number of events is 15 that meet the minimum criteria for a qualified sampling event. Collecting data from 15 events that meet the EPA criteria would likely require several years in Boise and a substantial investment in time and resources.

However, ACHD could use a combination of the approaches outlined in the reviewed literature to conduct a quantitative effectiveness evaluation of the nonstructural stormwater control practices implemented in the Phase I Permit Area. Results of effectiveness evaluations conducted for ACHD activities could provide a more refined estimate of reductions in pollution discharged to receiving waters. Information from local analysis could also be applied to stormwater management decisions regarding identification and prioritization of those portions of the MS4 where additional controls can be accomplished and current practices can be adjusted to decrease pollutant discharges to receiving waters.

Section 4

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Supplemental Reapplication Materials

Monitoring Data Statistical Analysis and Review of Alternative Monitoring Approaches Evaluations

Monitoring Data Statistical Analysis and Review of Alternative Monitoring Approaches

Prepared for

Ada County Highway District

Boise, Idaho

October 31, 2017

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Section 1

Introduction and Background

Ada County Highway District (ACHD) began collecting stormwater characterization samples from multiple sites following the issuance of the first Phase I National Pollutant Discharge Elimination System (NPDES) permit in Water Year (WY) 2000. Stormwater outfall monitoring continues under the current permit, which was issued in 2013. As part of this monitoring effort, ACHD has compiled flow weighted composite and grab sample results for over 17 years with at least three samples per year at each site. After the issuance of the 2013 permit, ACHD discontinued monitoring at four outfall monitoring stations and added four new monitoring locations to further expand the dataset. ACHD has now characterized stormwater runoff from more than 2,000 acres of urban watershed and has compiled an extensive dataset that characterizes stormwater runoff from the Phase I Municipal Separate Storm Sewer System (MS4).

The stormwater characterization efforts have provided important information on the quality and quantity of stormwater emanating from the MS4 in the Phase I area. In communities across the country, permittees have conducted similar characterization studies. In many cases the permittees have concluded that characterization monitoring developed a good baseline dataset that proved beneficial in estimating pollutant loads and characterizing stormwater of different land uses and types of watersheds within the MS4. Although monitoring efforts have greatly improved ACHD's capacity to characterize stormwater within the MS4, it has proven to be limited at identifying or quantifying effectiveness of stormwater management practices, estimating MS4 pollutant loads, or supporting area prioritization to further reduce pollutants.

This document provides a review of the statistical variability of the existing dataset to determine if continued monitoring at the established outfall monitoring locations will improve characterization of the stormwater discharging from the MS4. ACHD plans to leverage the existing dataset to focus monitoring on influent/effluent sites within the characterized watersheds. ACHD is seeking flexibility in the next permit to allow monitoring at various, strategically selected points higher up in the subwatersheds already characterized (and not just established outfall monitoring sites), while not comprehensively increasing the current monitoring requirements. This would allow ACHD to evaluate other program objectives that may help to better evaluate the effectiveness of the Storm Water Management Plan as a whole.

The proposed strategic monitoring approach serves specific purposes other than characterizing stormwater at the ultimate discharge point to receiving waters and could be used to improve the Stormwater Management Program in the following ways:

- target best management practices (BMPs) within the subwatersheds to evaluate the effectiveness of specific structural controls, green stormwater infrastructure solutions, and other nonstructural BMPs
- improve the understanding of small catchments and the methods used to delineate drainage area and land uses
- validate assumptions associated with hydraulics, hydrology, and pollutant source loads used in reports and modelling efforts

Section 2 of this report provides a statistical evaluation of the variability in stormwater quality monitoring data collected under the 2013 permit. For context, the results of the statistical analysis of monitoring data collected under the 2000 permit are added to the results from current analysis in the discussion portion of Section 2. Overall, the evaluation provides support for decreasing characterization efforts at outfalls to receiving waters in the next permit cycle.

Section 3 further reviews the objectives of a monitoring program and how different programs have developed monitoring plans to meet their objectives. In general, the primary objectives of many monitoring plans include one or more of the following: meet permit monitoring requirements, identify or track trends, evaluate the effectiveness of specific controls, compare to water quality standards, identify sources of pollutants of concern, and/or estimate pollutant loads. Based on these primary objectives, Section 3 provides examples of alternative monitoring approaches that ACHD could incorporate into the stormwater monitoring program to better meet the monitoring objectives identified by ACHD and stated above.

Section 2

Review of Monitoring Data Collected under 2013 NPDES Permit

A statistical analysis was conducted on the stormwater monitoring dataset to determine the degree of variability in the dataset. The variability that exists in the dataset is an indication of the level of need for additional data to adequately characterize stormwater runoff from the monitored drainage area. This section provides specific information about the approach used for statistical analysis and the statistics run on the monitoring dataset. Results and implications of the analysis are described in this section and in the associated tables and figures.

2.1 Data Included in Review

Analysis included data from November 2013 to May 2017 for five monitoring locations: Americana, Lucky, Main, Stilson, and Whitewater. The following list of analytes were evaluated.

Field Parameter Analytes

- pH
- temperature
- dissolved oxygen
- conductivity

Laboratory Sample Analytes

- turbidity
- *E. coli*
- biochemical oxygen demand 5-day (BOD5)
- chemical oxidation demand (COD)
- total suspended solids (TSS)
- total dissolved solids (TDS)
- hardness
- nutrients (total phosphorus, dissolved ortho phosphorus, ammonia, total Kjeldahl nitrogen [TKN], nitrate+nitrite)
- total metals (arsenic, cadmium, lead, mercury)
- dissolved metals (cadmium, copper, lead)

All laboratory sample analyte results, except *E. coli*, represent an event mean concentration (EMC) derived from flow weighted composite sample collection. Discrete grab samples were collected for laboratory analysis for *E. coli*, and discrete grab sample collection was coincident with field parameter measurements. Laboratory sample data were compared to water quality standards, where available (listed in Table 1). Data for the Lucky monitoring site from 2013–2017 were also compared to a longer-term dataset from 1999–2017.

2.2 Methods

Summary statistics were selected for use in generating box and whisker plots for each parameter at each site and to represent the degree of variability in the dataset. Box and whisker plots present the shape of the distribution, central value, and variability of the sample population. Statistics were generated using ProUCL and Microsoft Excel for all constituents. The summary statistical output includes the following parameters:

- Number of detected values, number of non-detects, and percentage of non-detects
- Minimum, maximum, mean, and median
- Standard deviation (SD)
- Skewness
- Coefficient of variation (CV): the ratio of the SD to the mean

2.3 Results

Results for field parameter and laboratory sample analytes are discussed in the subsections below. Information presented in tables and figures are included as attachments at the end of the report text.

2.3.1 Field Parameter Analytes

Field parameter analyte statistics are shown for individual sites in Table 2. There were no non-detects for grab sample analytes in the 2013–2017 dataset. The CV for all parameters was less than one, meaning measurements were fairly centered around the mean, with a low standard deviation for each dataset.

Box and whisker plots were developed to represent field parameter statistical analysis results and show the range of values for each field parameter analyte for the five monitoring sites. The box and whisker plots represent the minimum measured value (low whisker), maximum measured value (high whisker), first quartile (bottom of blue box), third quartile (top of red box), and median measured value (division between blue and red). Each figure also describes the applicable water quality standards. Figures 1 through 4 include box and whisker plots for each site from the current permit, (2013–2017), showing dissolved oxygen, temperature, pH, and conductivity, respectively. Figures 5 through 8 show the comparison between 2013–2017 data and 1999–2017 data for the Lucky monitoring site, for dissolved oxygen, temperature, pH, and conductivity, respectively.

2.3.2 Laboratory Sample Analytes

Laboratory sample analyte statistics for Americana, Lucky, Main, Stilson, and Whitewater are shown in Tables 3 through 7, respectively. Tables also identify the number of non-detects for each analyte. The number of non-detects was low enough for statistical analysis for all analytes except certain metals, for which a high percentage of sample results were non-detect. There were no detectable concentrations at any site for dissolved cadmium or dissolved lead. Figures 9 through 25 show the range of laboratory sample analyte measurements for each site for the current permit. Figures 26 through 39 show the comparison between 2013–2017 data and 1999–2017 data for the Lucky site for laboratory sample analytes. Due to non-detects, data was unavailable for comparison for total and dissolved lead, total and dissolved cadmium, and total arsenic. Each figure also describes the applicable water quality standards.

2.3.3 Comparison of Statistical Results between Permits

Evaluating CV results for each dataset provides an indication of the extent of variability in sample data from each monitoring site. Typically, a CV of less than 1 is considered to be a low-variance dataset, meaning the dataset is relatively consistent. CV results were less than one for the majority of laboratory sample analytes that represent an EMC (*E. coli*, is excluded from this finding). Exceptions include total phosphorus, TSS, and total lead at Main which were 1.21, 1.03, and 1.60, respectively, and turbidity, TSS, TDS, total cadmium, total lead, total mercury, and dissolved zinc at Stilson. CV values for the listed analytes at Stilson ranged from 1.05 to 1.34. CV values for *E. coli* ranged from 1.36 to 3.04 across all sites.

Monitoring data has been collected at the Lucky monitoring station over the course of both permits, which allows for an evaluation of variability as the number of data points increases. Table 8 includes a summary of mean, standard deviation, and CV values for laboratory sample analytes at Lucky for the 2000 permit dataset, 2013 permit dataset, and entire dataset. Figure 40 plots CV values for each analyte and dataset. Comparing CV values across each dataset shows that adding more data does not always result in a decrease in CV results and can increase CV in the overall dataset.

2.4 Conclusions and Implications

Overlap in the middle quartiles of plots from different sites suggests that pollutant concentrations in stormwater runoff with all events considered was not highly variable between sites. *E. coli* data consistently showed the highest CV at all sites. This result is expected given the variable nature of *E. coli* data in stormwater and the difference in sample collection methods: discrete grab sample collection for *E. coli* versus flow weighted composite samples (producing an EMC) for all other laboratory analytical samples.

The dataset shows CV values less than 1 for most analytes across all sites, with data generally centered around the mean. Adding to the dataset at Lucky did not result in substantially decreased CV results for all analytes and actually increased CV results for certain analytes. Together, these conclusions indicate that stormwater discharges at the monitored outfalls have been well characterized, and monitoring for an additional permit term under the same conditions is not likely to substantially decrease variability in the dataset. The dataset evaluation infers that data collected to date is representative of the stormwater quality emanating from the MS4. Further characterization studies would have a limited impact on the statistics of the dataset.

Section 3

Monitoring Alternatives to Support Program Goals

3.1 Approach

When developing a monitoring program, it is critical that each permittee identify the objectives of the monitoring program. The objective could be as specific as evaluating different BMPs for removal efficiencies of total phosphorus or as broad as meeting the permit-required monitoring.

According to the Federal Highway Administration, "The primary purpose of a monitoring program should be to obtain information necessary to make sound resource management decisions. For example, a typical stormwater monitoring program may be intended to identify pollution problem areas and determine which problem(s) are the most significant. Monitoring results would then be used to develop control strategies and prepare plans and budget estimates for addressing those problems." (https://www.environment.fhwa.dot.gov/ecosystems/h2o_runoff/h2oroch2.asp) Almost all the available guidance documents, identify the program objective as the driver for the monitoring program. In general, most monitoring programs work to address one or more of the following objectives:

- Identify or track trends
- Evaluate the effectiveness of specific controls (BMPs)
- Compare to water quality standards
- Identify sources for pollutants of concern
- Estimate stormwater pollutant loads
- Meet basic permit objectives

According to the EPA, "There are many components involved in monitoring and evaluating the effectiveness of a municipal stormwater program. Any comprehensive monitoring program should have clear monitoring objectives to help determine compliance and water quality impacts. Each monitoring program is unique and should be customized to the specific waterbodies, impairments, and pollutant sources of the MS4." (https://www.epa.gov/sites/production/files/2015-11/documents/ms4permit_improvement_guide1.pdf)

The federal minimum stormwater monitoring requirements are located in 40 Code of Federal Regulations 122.26 (d). These specific requirements include (but are not limited to) the following list:

- Quantitative data collected at 5–10 outfalls representing commercial, residential, and industrial land use activities of the drainage include the following list:
  - Samples shall be collected from three storm events, 1 month apart
  - Narrative description of the event must be provided
  - Samples shall be collected for the following analytes: TSS, TDS, COD, BOD5, oil and grease, fecal coliform, fecal streptococcus, pH, TKN, nitrate + nitrite, dissolved phosphorus, total ammonia plus organic nitrogen, and total phosphorus

   – Additional quantitative data required by the director

- Estimates of the annual pollutant load of the cumulative discharges to waters of the U.S. from all identified municipal outfalls and the EMC of the cumulative discharges
- A proposed schedule to provide estimates for each major outfall identified for the seasonal pollutant load
- A proposed monitoring program for representative data collection for the term of the permit

These requirements are broad in nature to allow the permittees and the regulated authority the flexibility to develop a program that helps them evaluate the effectiveness of the Storm Water Management Plant (SWMP) through monitoring.

The basic objectives of stormwater monitoring for the current permit are identified in permit part IV.A.2. The permittees are required to develop a monitoring and evaluation program to:

- Broadly estimate reductions in annual pollutant loads of sediment, bacteria, phosphorus, and temperature discharged to impaired receiving waters from the MS4s, occurring as a result of the implementation of SWMP activities
- Assess the effectiveness and adequacy of the permanent stormwater controls and low impact development techniques or controls selected for evaluation by the permittees and which are intended to reduce the total volume of stormwater discharging from impervious surfaces and/or improve the overall pollutant reduction in stormwater discharges
- Identify and prioritize those portions of each permittee's MS4 where additional controls can be accomplished to further reduce total volume of stormwater discharged and/or reduce pollutants in stormwater discharges to waters of the U.S.

Based on this requirement, ACHD has been conducting individual monitoring programs to help with the effectiveness evaluation of specific stormwater controls and has been conducting the aforementioned stormwater characterization monitoring.

Permittees have developed a wide array of approaches to meet the regulatory minimum and program objectives. For this document, those approaches were broken into three different categories, driven mostly by the primary objective for each program. In all situations presented below, secondary objectives can be found in many different approaches. Ultimately, once the permittee determines the primary objective, that objective can be combined with any of the other objectives to develop a program that fits the permittee's specific needs.

Considering the minimum requirements for each Phase I monitoring program as identified above, permittees can determine the objective for the monitoring program. Table 3.2 provides a summary of some of the common objectives for different monitoring programs as they compare to the three alternatives presented in this document.

Table 3.2. Monitoring Objectives and Approaches

Approach	Identify or track trends	BMP effectiveness	Compare to water quality standards	Identify sources	Estimate loads	Meet permit requirements
Subwatershed outfall monitoring	Yes	No	Yes	No	Yes	Yes
BMP monitoring	No	Yes	Yes	Yes	Yes	Yes
Watershed monitoring	Yes	No	Yes	No	Yes	Yes

This table is adapted in each subsection to provide a quick glance at the mixture of objectives identified in the examples presented.

In many areas across the country, communities are discovering that a diverse and strategic approach to monitoring can provide the most valuable results. This approach could be a combination of the monitoring alternatives described below. Results from each monitoring approach, combined with a strategic modeling plan can help the permittee not only meet the basic requirements of the permit but develop a strategic approach to monitoring that allows the permittee to cost-effectively manage stormwater assets for the long-term.

3.2 Alternative Approach – Subwatershed Outfall Monitoring

Table 3.3. Monitoring Objectives and Approaches

Approach	Identify or track trends	BMP effectiveness	Compare to water quality standards	Identify sources	Estimate loads	Meet permit requirements
Watershed outfall monitoring	Yes, requires numerous data points	No, can identify a decrease but cannot source the decrease	Yes	No	Yes, for the specific subwatershed	Yes

This alternative is the most similar to the current monitoring program conducted for the Phase I permit, and many permittees have adopted this approach to characterizing stormwater runoff from the MS4. The primary objective of this monitoring approach is to meet the regulatory compliance requirements identified in Section 3.1. In addition, many communities use this approach to meet a secondary objective “establish the current status of water quality and identify long term trends within each subwatershed” (City of Richmond, VA, Integrated Monitoring Plan).

Meeting the primary objective is relatively straight forward and requires the permittee to ensure that the monitoring plan includes the requirements identified in Section 3.1. The secondary objective is much more difficult to execute and measure. The variability in stormwater quality results make the identification of long-term trends difficult and requires extensive monitoring to gather enough data points that allow the permittee to clearly identify trends.

In order to remove variables from the equation, the permittee will need to identify subwatershed monitoring locations that have the following characteristics as conditions:

- Little to no influent groundwater or irrigation return in the system
- Understood connections to structural BMPs and the stormwater runoff conveyance system
- Known and delineated land use
- A schedule of nonstructural BMP implementation schedules.

The primary objective of this approach is to meet the permit monitoring requirements. The secondary objective in this situation is to determine whether the SWMP practices are having a positive impact on stormwater quality. In this case study, the permittee has identified multiple objectives with the primary objective identified as meeting the permit monitoring criteria. The secondary objective is evaluating the effectiveness of the SWMP on stormwater within the subwatershed.

3.3 Alternative Approach – BMP Effectiveness Monitoring

Table 3.4. Monitoring Objectives and Approaches

Approach	Identify or track trends	BMP effectiveness	Compare to water quality standards	Identify sources	Estimate loads	Meet permit requirements
BMP monitoring	No, does not connect to receiving waters	Yes	Yes, effluent concentrations can be compared to WQ standards	Yes	Yes	Yes

BMP effectiveness monitoring has become a much more controllable and predictable method for evaluating the success of a SWMP. The development of statewide performance certification programs and the guidance provided in the Urban Stormwater BMP Performance Monitoring Manual have normalized this approach and attempt to normalize the data collected from BMP effectiveness monitoring. In many areas across the country, permittees have joined together to monitor different BMPs in the area to better quantify how well certain BMPs work under the watershed's specific conditions (rainfall duration, rainfall intensity, soil conditions, impervious conditions, etc.). In addition to these resources, the International Stormwater BMP Database provides numerous resources and effectiveness results for a wide array of stormwater BMPs.

In Washington, the Department of Ecology developed the Stormwater Action Monitoring (SAM) Program, a cost share BMP evaluation program. Phase I and Phase II communities within Western Washington can opt to either fully engage in the program, opt out of the program, or partially engage in the program. Currently the program has 91 cities, towns, or counties and Washington State Department of Transportation members. The SAM program was developed to meet the following objectives:

- Identify receiving water trends: measure whether things are getting better or worse and identify patterns in healthy and impaired Puget Lowland streams and Puget Sound urban shoreline areas
- Monitor effectiveness: provide widely applicable information about what works and what doesn't work in certain situations and how to improve stormwater management
- Identify sources: provide information about source identification and elimination methods and identify opportunities for regional solutions to common illicit discharges in the pollution problems
- Administer pooled funds: credible and transparent accountability for expenditures of permittee funds to implement SAM

Most of the objectives in this example include watershed level goals, the BMP monitoring and source identification monitoring, specifically, support the permit requirements and the improvement of stormwater quality emanating from the MS4. The overall objective of the monitoring program is to support the larger watershed monitoring objective of measuring the effectiveness of stormwater management actions watershed wide.

Although this type of approach may or may not be an option for the permittees in the Lower Boise River watershed it demonstrates that the clear identification of an objective can provide numerous options for meeting that objective.

3.4 Alternative Approach – Watershed Monitoring

Table 3.5. Monitoring Objectives and Approaches						
Approach	Identify or track trends	BMP effectiveness	Compare to water quality standards	Identify sources	Estimate loads	Meet permit requirements
Watershed monitoring	Yes	Yes	Yes	Yes	Yes	Yes

In many cases, local and state regulations drive the monitoring requirements for the permittees. In some situations, communities within a watershed have joined together and provided justification to the state regulatory authority to change the direction associated with stormwater monitoring from one of characterization to one that evaluates more specific stormwater impacts to waters of the U.S. In these situations, local concerns can include hydromodification, strict total maximum daily load (TMDL) requirements, and groundwater recharge and water quality. The approach changes from outfall monitoring to instream, source identification, benthic and groundwater monitoring.

In an example from Clackamas County Oregon the following objectives are identified in the permit:

- Evaluate the sources of the 303(d) listed pollutants applicable to the permittee
- Evaluate effectiveness of BMPs
- Characterize stormwater based on land use type, seasonality, geography, or other catchment characteristics
- Evaluate status and long-term trends in receiving waters
- Assess the chemical, biological, and physical effects of stormwater discharges on receiving waters
- Assess progress towards meeting TMDL load reduction benchmarks

In this approach, the permittees monitor outfalls from subwatersheds that comprise specific land use types. The outfall monitoring results are compared to upstream and downstream instream monitoring results. In 2006, the permittees in this watershed developed a document that evaluated the comprehensive stormwater characterization results of the initial 6 years of the permit. They engaged the regulator to change the monitoring requirement to provide more flexibility to the permittees on how to evaluate the effectiveness of stormwater management actions in multiple ways. The permit conditions above are a result of that request. This case study presents a solution that resulted from identifying a primary objective, engaging the regulator, and demonstrating the value of the objective to change the direction of subsequent permits.

A more traditional watershed level monitoring program is the Hampton Roads Regional Water Quality Monitoring Program in the Chesapeake Bay watershed. This program conducts watershed level monitoring to more accurately meet the following objectives:

- Characterize sediment and nutrient loadings from the major types of urban land-uses in the Hampton Roads Region
- Compare the measured sediment and nutrient loads to Chesapeake Bay Watershed Model loadings and allocations to support improving the accuracy of the model in the Coastal Plain

This approach includes continual flow monitoring, continuous water quality monitoring (temperature, conductivity, and turbidity), and stormwater event sampling.

3.5 Conclusions and Further Information/Decisions Needed

The Oregon Association of Clean Water Agencies commissioned an evaluation in order to identify the sample size required to statistically detect changes in mean pollutant concentrations over time. The following percent reductions required the associated sample size to detect statistical trends:

- 5 percent reduction in total phosphorus would require between 105 and 244 (depending on land use) sample points
- 20 percent reduction in total phosphorus would require between 8 and 16 sample points
- 50 percent reduction in total phosphorus would require between 3 and 4 sample points.

In situations where reductions are clearly occurring, the permittee would not need to conduct very many sample events to confirm the trend. However, in most situations (as was evident in the ACHD monitoring results), database evaluation may identify minor trends, and the amount of additional monitoring required to statistically detect those trends is significant and may require a long-term time and resource commitment that would result in a minor reduction calculation.

After reviewing the resources available and comparing the ACHD permit and monitoring program with other programs across the country, it becomes more apparent that many communities are running into the same issues regardless of local hydrology and climate conditions. Clear and concise objectives will help the permittee to develop a monitoring program that can meet multiple objectives. ACHD currently conducts all three of the approaches identified in this review to some extent. However, by refining the objectives and connecting the monitoring programs, ACHD can more cost-effectively evaluate the success of the ACHD-preferred stormwater management practices and recommend additional controls that maximize the reduction of pollutants of concern to waters of the U.S.

ACHD is preparing to receive a new Phase I permit. The conditions of that permit have not been presented to the permittees. If the permit language includes additional flexibility in monitoring requirements, ACHD can review the permit requirements and monitoring approach examples to determine a course of action that results in a monitoring program that can meet multiple objectives.

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Table 1. Water Quality Standards			
Constituent	**Standard**	**Basis**	**Source/ comment**
pH	6.5 to 9.0 SU	aquatic life	IDAPA 58.01.02.250.01.a
Temperature	Acute: 22	aquatic life	IDAPA 58.01.02.250.01.b
	Max day avg: 19		
Conductivity	NA	NA	NA
Dissolved oxygen	Acute: < 5.0 mg/l	aquatic life (salmonid spawning)	IDAPA 58.01.02.278.01
	Chronic: < 6.0 mg/l		
Turbidity	Acute: > 50 NTU	aquatic life	IDAPA 58.01.02 Standards are above background
	Chronic: > 10 NTU		
E. coli	Acute: 406 CFU/100 ml	recreation	IDAPA 58.01.02.251.01.c
	Geomean: < 126 CFU/100ml		
BOD	NA	NA	NA
COD	NA	NA	NA
TDS	500 mg/l	drinking water supply	National Secondary Drinking water standards
Total suspended solids	Acute: 80 mg/l	aquatic life	TMDL
	Chronic: 50 mg/l		
Total phosphorus	May–Sep: < 0.07 mg/l	eutrophication, aquatic life	TMDL
Ammonia	NA	NA	NA
Nitrate+Nitrite	10 mg/l	drinking water supply	National Primary Drinking water standards
TKN	NA	NA	NA
Arsenic	Acute: 340 ug/l	aquatic life	IDAPA 58.01.02
	Chronic: 150 ug/l		
	Domestic: 10 ug/l		
Cadmium	Acute: 1.3 ug/l	aquatic life	IDAPA 58.01.02
	Chronic: 0.6 ug/l		
Copper	Acute: 17 ug/l	aquatic life	IDAPA 58.01.02
	Chronic: 11 ug/l		
Lead	Acute: 65 ug/l	aquatic life	IDAPA 58.01.02
	Chronic: 2.5 ug/l		
Mercury	Acute: 2.1 ug/l	aquatic life	IDAPA 58.01.02
	Chronic: 0.012 ug/l		
Zinc	Acute: 120 ug/l	aquatic life	IDAPA 58.01.02
	Chronic: 120 ug/l		

Notes:

NA: Not applicable

Table 2. Field Parameter Results for Individual Sites											
Site	Variable	Number Detects	Number Non-Detects (ND)	% Non-Detects	Minimum	Maximum	Mean	Median	SD	Skewness	CV
Lucky	Dissolved Oxygen (mg/L)	14	0	0	1.72	10.28	6.64	6.35	2.84	-0.22	0.43
	Temperature (°C)	25	0	0	4.8	22.3	12.05	11.75	4.53	0.51	0.38
	pH (S.U.)	14	0	0	6.46	8.95	7.77	7.69	0.73	0.03	0.09
	Conductivity (uS/cm)	14	0	0	51.2	356.5	140.49	103.2	101.99	1.18	0.73
American	Dissolved Oxygen (mg/L)	15	0	0	6.85	10.83	8.43	8.23	1.37	0.59	0.16
	Temperature (°C)	15	0	0	6.7	19.8	12.57	12	3.6	0.57	0.29
	pH (S.U.)	15	0	0	6.51	8.23	7.55	7.85	0.62	-1.86	0.08
	Conductivity (uS/cm)	15	0	0	120	662	236.99	225.6	133.91	2.47	0.57
Main	Dissolved Oxygen (mg/L)	15	0	0	5.56	11.06	8.38	8.36	1.68	-0.28	0.2
	Temperature (°C)	15	0	0	5.6	23.9	11.34	9.7	5.1	1.09	0.45
	pH (S.U.)	15	0	0	4.99	8.85	7.59	8.09	1.09	-1.1	0.14
	Conductivity (uS/cm)	16	0	0	2.2	542	156.56	128.9	135.47	1.79	0.87
Stilson	Dissolved Oxygen (mg/L)	14	0	0	5.21	12.02	8.69	9.15	1.94	-0.43	0.22
	Temperature (°C)	14	0	0	6.1	22.8	11.9	9.9	5.16	-0.43	0.43
	pH (S.U.)	25	0	0	6.47	8.58	7.94	8.07	0.55	-1.69	0.07
	Conductivity (uS/cm)	14	0	0	64.7	370.4	187.09	167.15	90.33	0.91	0.48
Whitewater	Dissolved Oxygen (mg/L)	14	0	0	3.91	9.37	6.55	6.69	1.78	0.13	0.27
	Temperature (°C)	14	0	0	6.7	21.7	12.44	11.6	4.11	-0.43	0.33
	pH (S.U.)	13	0	0	5.22	8.41	7.61	7.86	0.86	-2.12	0.11
	Conductivity (uS/cm)	13	0	0	132.5	342.9	230.57	206.8	74.32	0.35	0.32

Table 3. Laboratory Sample Analyte Results for Americana										
Variable	Number Detects	Number Non-Detects	% Non-Detects	Minimum	Maximum	Mean	Median	SD	Skewness	CV
Turbidity (NTU)	18	0	0	11.2	280	77.42	60.8	63.93	2.08	0.83
Hardness as CaCO3 (mg/L)	18	0	0	30	155	61.46	50.4	33.26	1.89	0.54
E. coli (mpn/100 mL)	16	0	0	27.2	14,390	2,722.11	1,413.60	3,693.27	2.48	1.36
BOD_5 (mg/L)	17	0	0	8	62.9	26.03	23	15.8	1	0.61
COD (mg/L)	18	0	0	60.5	574	183.69	145	133.99	1.93	0.73
TSS (mg/L)	17	0	0	15.2	390	132.78	95.7	122.21	1.57	0.92
TDS (mg/L)	17	0	0	67	264	148.29	135	62.77	0.8	0.42
Total Phosphorus (mg/L)	18	0	0	0.24	1.43	0.56	0.45	0.3	1.58	0.53
Dissolved Orthophosphate (mg/L)	15	0	0	0.1	0.86	0.31	0.21	0.21	1.38	0.69
Ammonia (mg/L)	18	0	0	0.21	1.72	0.57	0.39	0.4	1.61	0.7
Nitrate + Nitrite (N) (mg/L)	15	0	0	0.26	0.71	0.47	0.47	0.14	0.26	0.3
TKN (mg/L)	18	0	0	1.04	9.35	2.85	1.85	2.48	2.09	0.87
Arsenic, total (ug/L)	3	15	83	<5.00	12	8.9	7.92	2.74	1.41	0.31
Cadmium, dissolved (ug/L)	0	15	100	<0.50	<0.50	NC	NC	NC	NC	NC
Cadmium, total (ug/L)	1	17	94	<0.50	2.24	NC	NC	NC	NC	NC
Copper, dissolved (ug/L)	9	6	40	3.7	15.7	9.58	9	4.74	0.28	0.49
Lead, dissolved (ug/L)	0	15	100	<4.00	<4.00	<4.00	<4.00	NC	NC	NC
Lead, total (ug/L)	15	2	12	<3.00	34.4	12.15	8.8	8.58	1.76	0.71
Mercury, total (ug/L)	17	1	6	0.01	0.05	0.02	0.02	0.01	0.84	0.48
Zinc, dissolved (ug/L)	15	0	0	16.2	116	40.45	34.7	26.35	1.82	0.65

Notes:

NC: Not calculated due to low number of detections

Table 4. Laboratory Sample Analyte Results for Lucky										
Variable	Number Detects	Number Non-Detects	% Non-Detects	Minimum	Maximum	Mean	Median	SD	Skewness	CV
Turbidity (NTU)	13	0	0	10.00	39.20	25.54	26.60	10.35	-0.17	0.41
Hardness as CaCO3 (mg/L)	14	0	0	13.00	66.30	32.56	31.80	15.32	0.66	0.47
E. coli (mpn/100 mL)	14	0	0	14.80	12,110.00	1,619.24	156.55	3,383.01	2.74	2.09
BOD5 (mg/L)	14	0	0	5.40	68.30	24.28	14.60	19.96	1.31	0.82
COD (mg/L)	14	0	0	52.00	212.00	100.71	87.25	43.56	1.46	0.43
TSS (mg/L)	14	0	0	9.08	79.30	36.11	35.70	19.13	0.73	0.53
TDS (mg/L)	14	0	0	39.00	151.00	89.90	83.65	37.53	0.26	0.42
Total Phosphorus (mg/L)	14	0	0	0.18	1.11	0.47	0.43	0.28	1.44	0.58
Dissolved Orthophosphate (mg/L)	13	0	0	0.10	0.76	0.29	0.22	0.21	1.57	0.71
Ammonia (mg/L)	13	0	0	0.09	1.00	0.53	0.59	0.31	-0.02	0.59
Nitrate + Nitrite (N) (mg/L)	13	0	0	0.10	0.72	0.34	0.34	0.18	0.96	0.54
TKN (mg/L)	14	0	0	0.55	4.10	1.92	1.80	1.04	0.85	0.54
Arsenic, total (ug/L)	1	15	94	6.97	6.97	6.97	6.97	NC	NC	NC
Cadmium, dissolved (ug/L)	0	15	100	NC	NC	NC	NC	NC	NC	NC
Cadmium, total (ug/L)	0	17	100	NC	NC	NC	NC	NC	NC	NC
Copper, dissolved (ug/L)	6	8	57	3.30	14.80	8.38	6.60	4.83	0.68	0.58
Lead, dissolved (ug/L)	0	15	100	NC	NC	NC	NC	NC	NC	NC
Lead, total (ug/L)	0	17	100	NC	NC	NC	NC	NC	NC	NC
Mercury, total (ug/L)	11	3	21	0.01	0.03	0.01	0.01	0.01	1.75	0.59
Zinc, dissolved (ug/L)	13	0	0	15.00	66.80	37.35	31.60	15.62	0.57	0.42

Notes:

NC: Not calculated due to low number of detections

Table 5. Laboratory Sample Analyte Results for Main										
Variable	Number Detects	Number Non-Detects	% Non-Detects	Minimum	Maximum	Mean	Median	SD	Skewness	CV
Turbidity (NTU)	14	0	0	14.80	344.00	86.52	63.95	84.69	2.49	0.98
Hardness as CaCO3 (mg/L)	14	0	0	16.90	79.60	32.18	23.95	18.65	1.63	0.58
E. coli (mpn/100 mL)	16	0	0	4.10	5,200.00	761.85	398.95	1,285.00	3.08	1.69
BOD5 (mg/L)	14	0	0	6.30	36.30	16.79	14.15	8.67	1.03	0.52
COD (mg/L)	13	0	0	56.00	466.00	149.88	148.00	106.37	2.41	0.71
TSS (mg/L)	12	0	0	11.10	495.00	105.54	75.90	127.60	3.00	1.21
TDS (mg/L)	13	0	0	46.00	146.00	78.45	72.80	29.20	1.12	0.37
Total Phosphorus (mg/L)	14	0	0	0.14	1.74	0.40	0.26	0.41	3.06	1.03
Dissolved Orthophosphate (mg/L)	14	0	0	0.06	0.24	0.13	0.11	0.06	0.76	0.47
Ammonia (mg/L)	14	0	0	0.30	1.19	0.76	0.68	0.29	0.22	0.39
Nitrate + Nitrite (N) (mg/L)	13	0	0	0.15	0.63	0.33	0.31	0.14	0.61	0.42
TKN (mg/L)	14	0	0	0.99	4.00	2.09	1.96	0.92	0.87	0.44
Arsenic, total (ug/L)	1	14	93	10.30	10.30	10.30	10.30	NC	NC	NC
Cadmium, dissolved (ug/L)	0	13	100	NC	NC	NC	NC	NC	NC	NC
Cadmium, total (ug/L)	3	12	80	0.60	2.47	1.25	0.68	1.06	1.72	0.85
Copper, dissolved (ug/L)	5	7	58	4.80	8.80	6.46	5.50	1.98	0.54	0.31
Lead, dissolved (ug/L)	0	13	100	NC	NC	NC	NC	NC	NC	NC
Lead, total (ug/L)	12	2	14	5.02	138.00	23.39	10.90	37.54	3.06	1.60
Mercury, total (ug/L)	14	1	7	0.01	0.06	0.02	0.02	0.02	1.78	0.64
Zinc, dissolved (ug/L)	13	0	0	23.30	61.60	36.64	32.70	13.00	0.87	0.35

Notes:

NC: Not calculated due to low number of detections

Table 6. Laboratory Sample Analyte Results for Stilson										
Variable	Number Detects	Number Non-Detects	% Non-Detects	Minimum	Maximum	Mean	Median	SD	Skewness	CV
Turbidity (NTU)	13	0	0	27.60	698.00	140.32	55.00	188.71	2.53	1.34
Hardness as CaCO3 (mg/L)	13	0	0	29.00	160.00	62.91	48.80	41.50	1.80	0.66
E. coli (mpn/100 mL)	14	0	0	15.80	86,640.00	7,450.94	653.20	22,882.95	3.69	3.07
Table 6. Laboratory Sample Analyte Res	13	0	0	7.90	98.70	30.19	25.30	23.30	2.34	0.77
COD (mg/L)	12	0	0	77.50	777.00	236.42	168.00	194.36	2.20	0.82
TSS (mg/L)	13	0	0	15.00	901.00	176.97	100.00	230.56	2.96	1.30
TDS (mg/L)	13	0	0	74.00	834.00	172.32	103.00	203.54	3.33	1.18
Total Phosphorus (mg/L)	13	0	0	0.22	0.89	0.51	0.40	0.24	0.39	0.47
Dissolved Orthophosphate (mg/L)	11	0	0	0.08	0.44	0.24	0.24	0.12	0.20	0.49
Ammonia (mg/L)	12	0	0	0.27	1.80	0.80	0.72	0.39	1.38	0.49
Nitrate + Nitrite (N) (mg/L)	12	0	0	0.15	0.62	0.35	0.36	0.13	0.43	0.38
TKN (mg/L)	12	0	0	1.10	5.10	2.85	2.76	1.33	0.37	0.46
Arsenic, total (ug/L)	1	12	92	15.50	15.50	15.50	15.50	NC	NC	NC
Cadmium, dissolved (ug/L)	0	12	100	NC	NC	NC	NC	NC	NC	NC
Cadmium, total (ug/L)	4	9	69	0.50	4.12	1.57	0.84	1.71	1.94	1.08
Copper, dissolved (ug/L)	6	5	45	4.80	13.40	8.37	8.15	3.28	0.52	0.39
Lead, dissolved (ug/L)	1	11	92	NC	NC	NC	NC	NC	NC	NC
Lead, total (ug/L)	11	2	15	4.00	78.70	23.62	13.00	25.47	1.74	1.08
Mercury, total (ug/L)	13	0	0	0.01	0.12	0.02	0.02	0.03	3.29	1.20
Zinc, dissolved (ug/L)	12	0	0	15.30	189.00	44.62	30.65	46.70	3.15	1.05

Notes:

NC: Not calculated due to low number of detections

Table 7. Laboratory Sample Analyte Results for Whitewater										
Variable	Number Detects	Number Non-Detects	% Non-Detects	Minimum	Maximum	Mean	Median	SD	Skewness	CV
Turbidity (NTU)	13	0	0	16.00	204.00	74.61	55.90	54.90	1.15	0.74
Hardness as CaCO3 (mg/L)	13	0	0	27.00	231.00	76.15	54.00	55.81	2.07	0.73
E. coli (mpn/100 mL)	13	0	0	6.30	4,640.00	468.03	135.40	1,257.27	3.57	2.69
BOD5 (mg/L)	13	0	0	7.90	64.20	24.83	18.50	16.64	1.33	0.67
COD (mg/L)	12	0	0	86.50	254.00	147.42	122.50	53.69	0.90	0.36
TSS (mg/L)	13	0	0	5.50	226.00	89.81	66.20	68.56	0.79	0.76
TDS (mg/L)	13	0	0	84.00	402.00	177.08	142.00	87.70	1.57	0.50
Total Phosphorus (mg/L)	13	0	0	0.35	1.17	0.59	0.46	0.26	1.24	0.45
Dissolved Orthophosphate (mg/L)	11	0	0	0.12	0.73	0.34	0.29	0.19	1.00	0.57
Ammonia (mg/L)	12	1	8	0.08	1.05	0.45	0.29	0.35	0.78	0.78
Nitrate + Nitrite (N) (mg/L)	12	0	0	0.16	1.41	0.54	0.43	0.35	1.79	0.64
TKN (mg/L)	13	0	0	1.00	4.10	2.08	1.80	1.03	0.89	0.49
Arsenic, total (ug/L)	3	10	77	6.30	9.78	8.55	9.56	1.95	-1.71	0.23
Cadmium, dissolved (ug/L)	0	12	100	NC	NC	NC	NC	NC	NC	NC
Cadmium, total (ug/L)	1	12	92	1.25	1.25	1.25	1.25	NC	NC	NC
Copper, dissolved (ug/L)	4	6	60	6.80	15.00	9.98	9.05	3.58	1.30	0.36
Lead, dissolved (ug/L)	0	12	100	NC	NC	NC	NC	NC	NC	NC
Lead, total (ug/L)	9	4	31	3.00	30.40	13.76	12.30	7.67	1.17	0.56
Mercury, total (ug/L)	12	1	8	0.01	0.05	0.02	0.02	0.01	1.92	0.63
Zinc, dissolved (ug/L)	11	1	8	10.20	61.40	27.95	24.10	14.58	1.14	0.52

Notes:

NC: Not calculated due to low number of detections

Table 8. Comparison of Results from Lucky									
	2000 Permit			2013 Permit			Both Permits		
Variable	Mean	Standard Deviation	Coefficient of Variance	Mean	Standard Deviation	Coefficient of Variance	Mean	Standard Deviation	Coefficient of Variance
Turbidity (NTU)	NC	NC	NC	25.54	10.35	0.41	NC	NC	NC
Hardness as CaCO3 (mg/L)	48.93	35.46	0.72	32.56	15.32	0.47	44.16	31.69	0.72
E. coli (mpn/100 mL)	1315.20	2901.25	2.21	1619.24	3383.01	2.09	1405.77	3018.22	2.15
BOD5 (mg/L)	33.52	29.00	0.87	24.28	19.96	0.82	30.82	26.81	0.87
COD (mg/L)	173.71	118.67	0.68	100.71	43.56	0.43	152.86	107.70	0.70
TSS (mg/L)	126.09	141.12	1.12	36.11	19.13	0.53	100.39	126.06	1.26
TDS (mg/L)	141.43	117.16	0.83	89.90	37.53	0.42	126.71	103.24	0.81
Total Phosphorus (mg/L)	0.71	0.44	0.63	0.47	0.28	0.58	0.64	0.42	0.65
Dissolved Orthophosphate (mg/L)	0.36	0.36	1.00	0.29	0.21	0.71	0.34	0.32	0.94
Ammonia (mg/L)	0.96	0.44	0.46	0.53	0.31	0.59	0.84	0.45	0.53
Nitrate + Nitrite (N) (mg/L)	0.58	0.24	0.42	0.34	0.18	0.54	0.51	0.25	0.49
TKN (mg/L)	3.42	2.00	0.59	1.92	1.04	0.54	2.99	1.90	0.63
Arsenic, total (ug/L)	3.34	2.40	0.72	6.97	NC	NC	3.45	2.45	0.71
Cadmium, dissolved (ug/L)	0.05	0.04	0.69	NC	NC	NC	0.05	0.04	0.69
Cadmium, total (ug/L)	0.40	0.76	1.91	NC	NC	NC	0.40	0.76	1.91
Copper, dissolved (ug/L)	8.71	7.51	0.86	8.38	4.83	0.58	8.66	7.09	0.82
Lead, dissolved (ug/L)	0.58	0.55	0.95	NC	NC	NC	0.58	0.55	0.95
Lead, total (ug/L)	7.94	8.76	1.10	NC	NC	NC	7.94	8.76	1.10
Mercury, total (ug/L)	0.03	0.01	0.31	0.01	0.01	0.59	0.02	0.01	0.58
Zinc, dissolved (ug/L)	NC	NC	NC	37.35	15.62	0.42	NC	NC	NC

Notes:

NC: Not calculated due to low number of detections

Figures

Figure 1. Dissolved oxygen measurements at all sites for 2013–2017
Figure 2. Temperature measurements at all sites for 2013–2017
Figure 3. pH measurements at all sites for 2013–2017
Figure 4. Conductivity measurements at all sites for 2013–2017
Figure 5. Dissolved oxygen measurements at Lucky for 2013–2017 and 1999–2017
Figure 6. Temperature measurements at Lucky for 2013–2017 and 1999–2017
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Figure 8. Conductivity measurements at Lucky for 2013–2017 and 1999–2017
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Figure 19. Nitrate + nitrite measurements at all sites for 2013–2017
Figure 20. Total Kjeldahl nitrogen measurements at all sites for 2013–2017
Figure 21. Total arsenic measurements at all sites for 2013–2017 (no findings for Lucky, Main, or Stilson)
Figure 22. Total cadmium measurements at all sites for 2013–2017
Figure 23. Dissolved copper measurements at all sites for 2013–2017
Figure 24. Total lead measurements at all sites for 2013–2017 (no findings for Lucky)

Figure 25. Total mercury measurements at all sites for 2013–2017

Figure 26. Turbidity measurements at Lucky for 2013–2017 and 1999–2017

Figure 27. Hardness measurements at Lucky for 2013–2017 and 1999–2017

Figure 28. E. coli measurements at Lucky for 2013–2017 and 1999–2017

Figure 29. Biological oxygen demand (5-day) measurements at Lucky for 2013–2017 and 1999–2017

Figure 30. Chemical oxygen demand measurements at Lucky for 2013–2017 and 1999–2017

Figure 31. Total suspended solids measurements at Lucky for 2013–2017 and 1999–2017

Figure 32. Total dissolved solids measurements at Lucky for 2013–2017 and 1999–2017

Figure 33. Total phosphorus measurements at Lucky for 2013–2017 and 1999–2017

Figure 34. Dissolved orthophosphate measurements at Lucky for 2013–2017 and 1999–2017

Figure 35. Ammonia measurements at Lucky for 2013–2017 and 1999–2017

Figure 36. Nitrate + nitrite measurements at Lucky for 2013–2017 and 1999–2017

Figure 37. Total Kjeldahl nitrogen measurements at Lucky for 2013–2017 and 1999–2017

Figure 38. Dissolve copper measurements at Lucky for 2013–2017 and 1999–2017

Figure 39. Total mercury measurements at Lucky for 2013–2017 and 1999–2017

Figure 40. Coefficient of Variation in Sample Results from Lucky by Permit

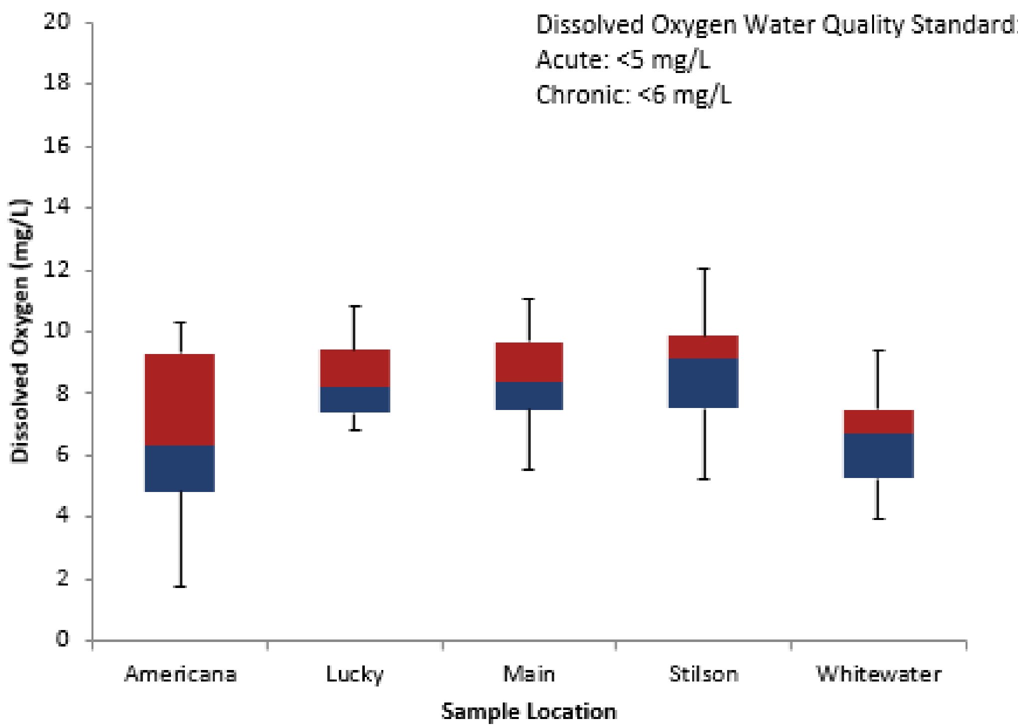

Figure 1. Dissolved oxygen measurements at all sites for 2013–2017

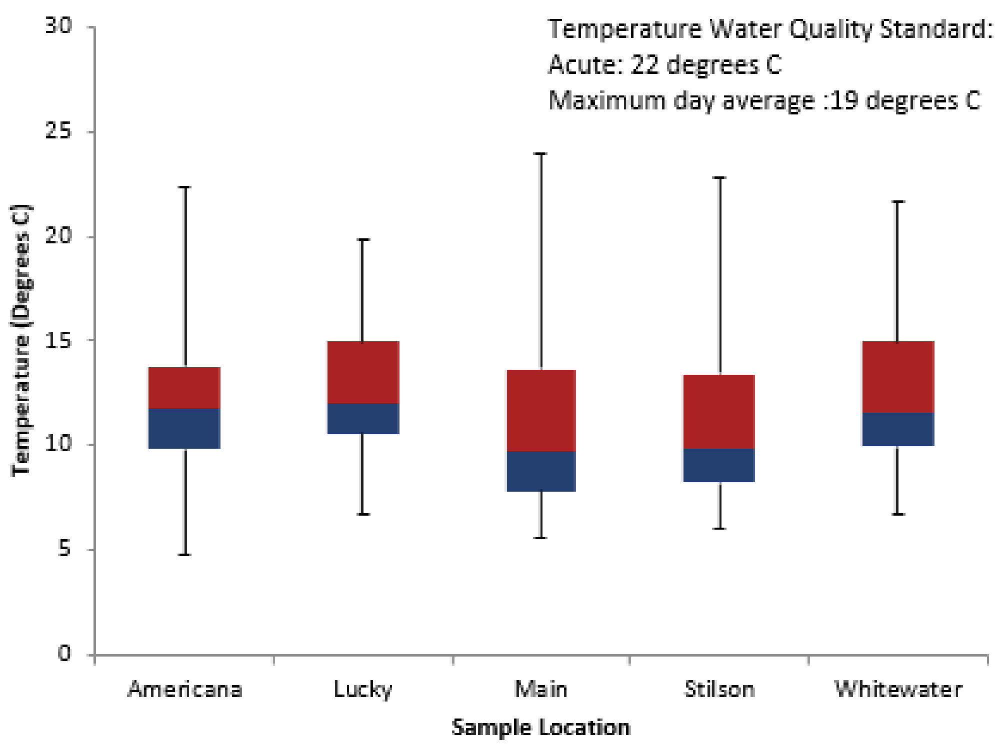

Figure 2. Temperature measurements at all sites for 2013–2017

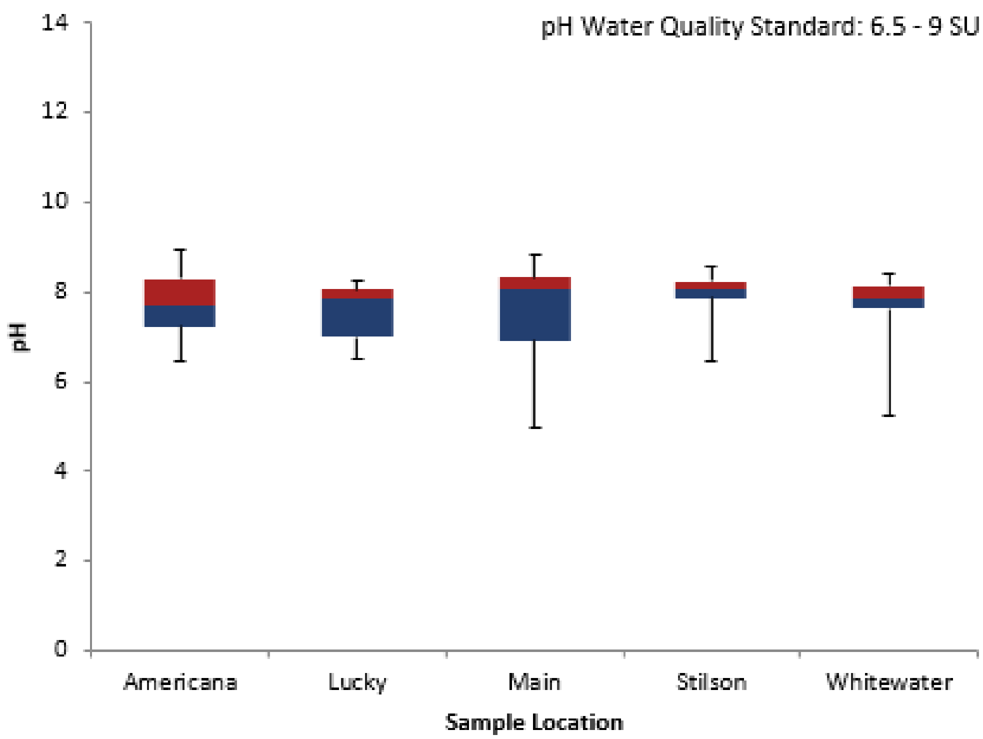

Figure 3. pH measurements at all sites for 2013–2017

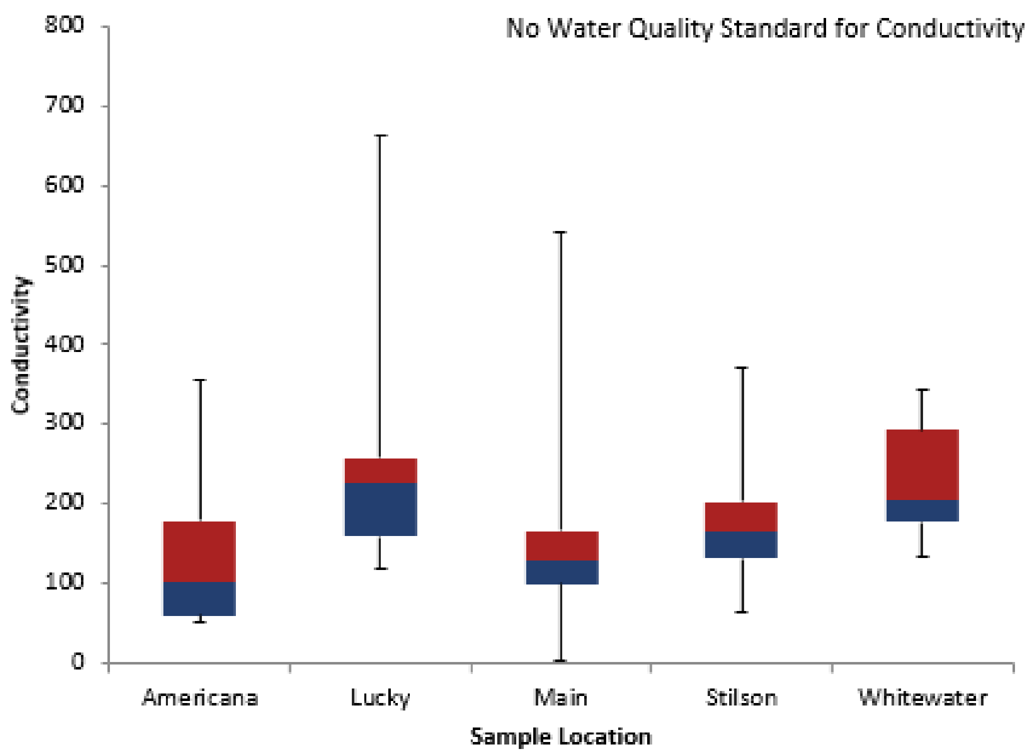

Figure 4. Conductivity measurements at all sites for 2013–2017

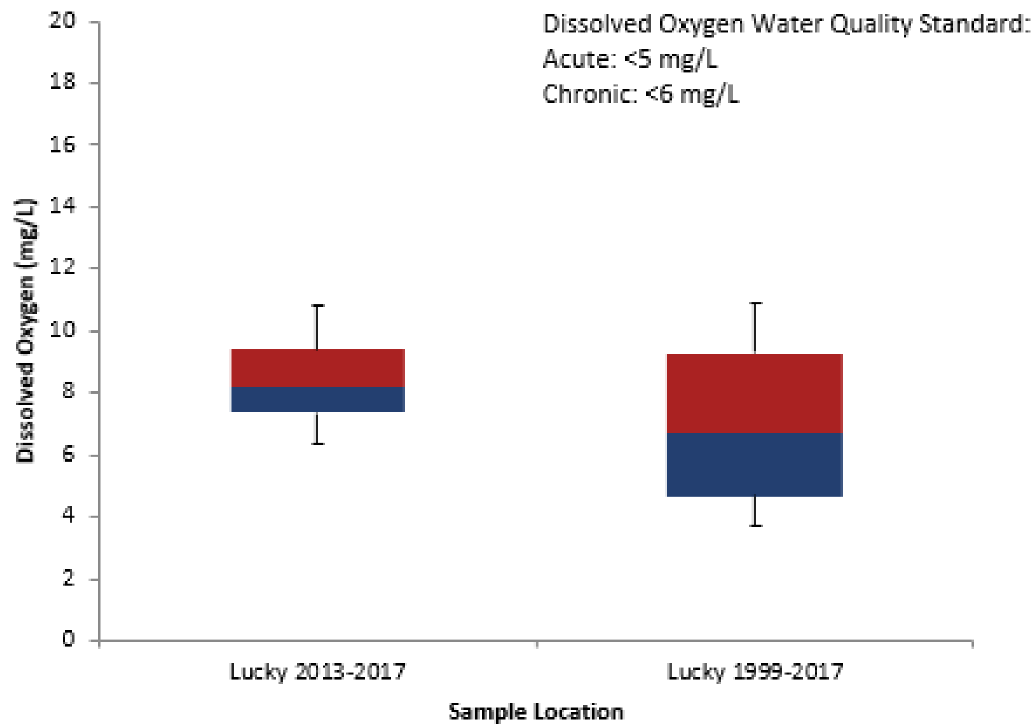

Figure 5. Dissolved oxygen measurements at Lucky for 2013–2017 and 1999–2017

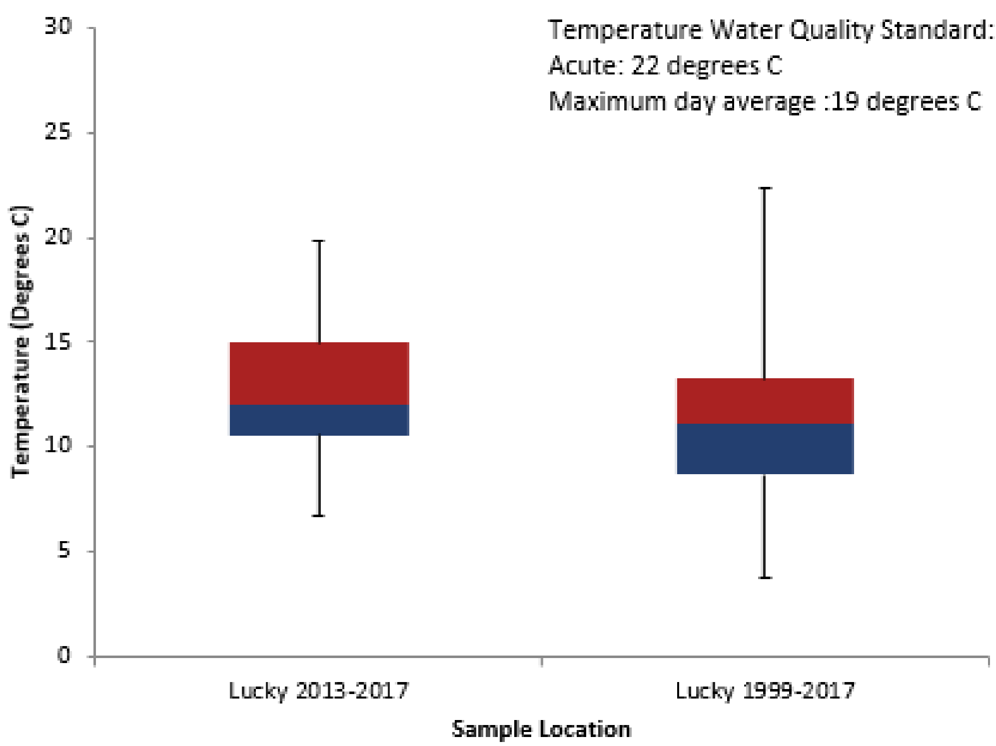

Figure 6. Temperature measurements at Lucky for 2013–2017 and 1999–2017

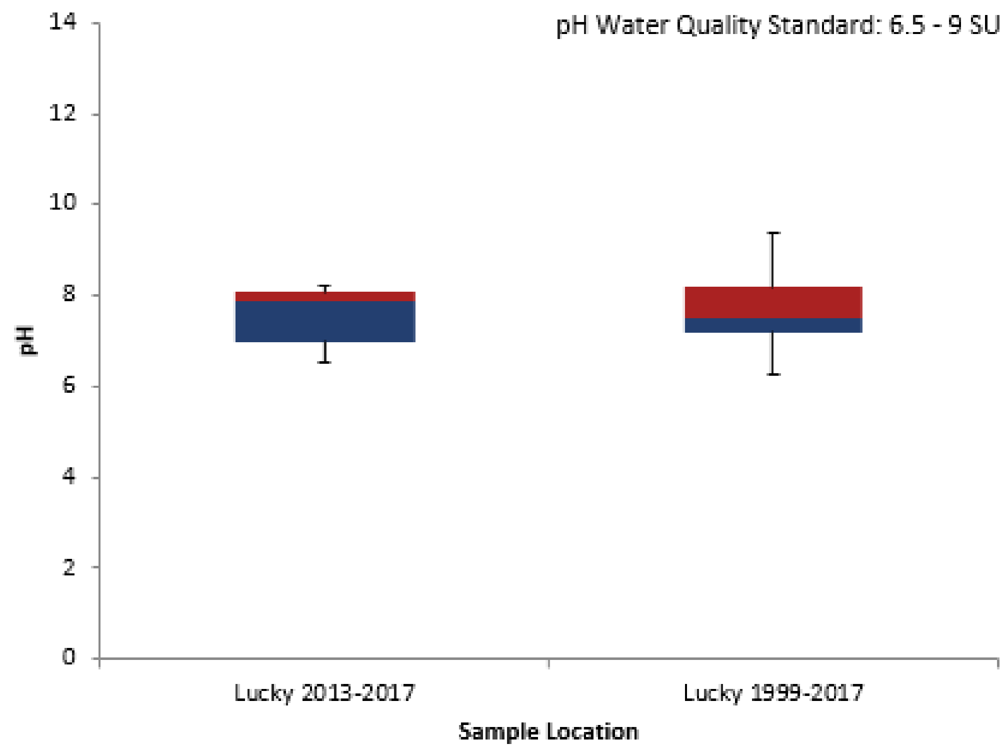

Figure 7. pH measurements at Lucky for 2013–2017 and 1999–2017

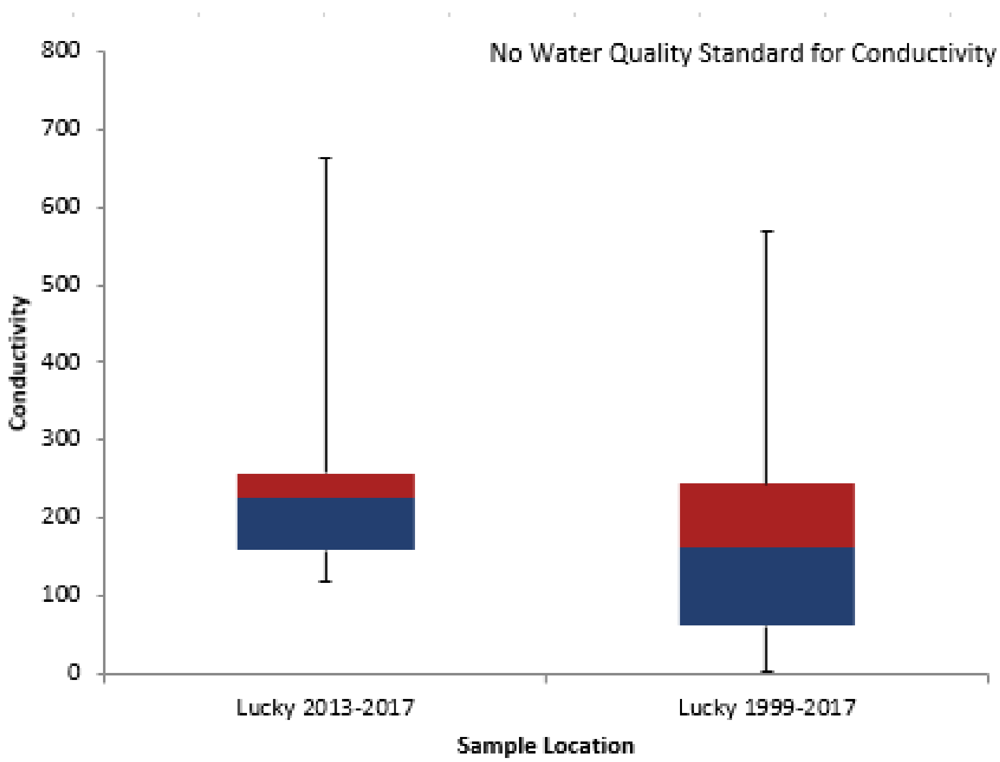

Figure 8. Conductivity measurements at Lucky for 2013–2017 and 1999–2017

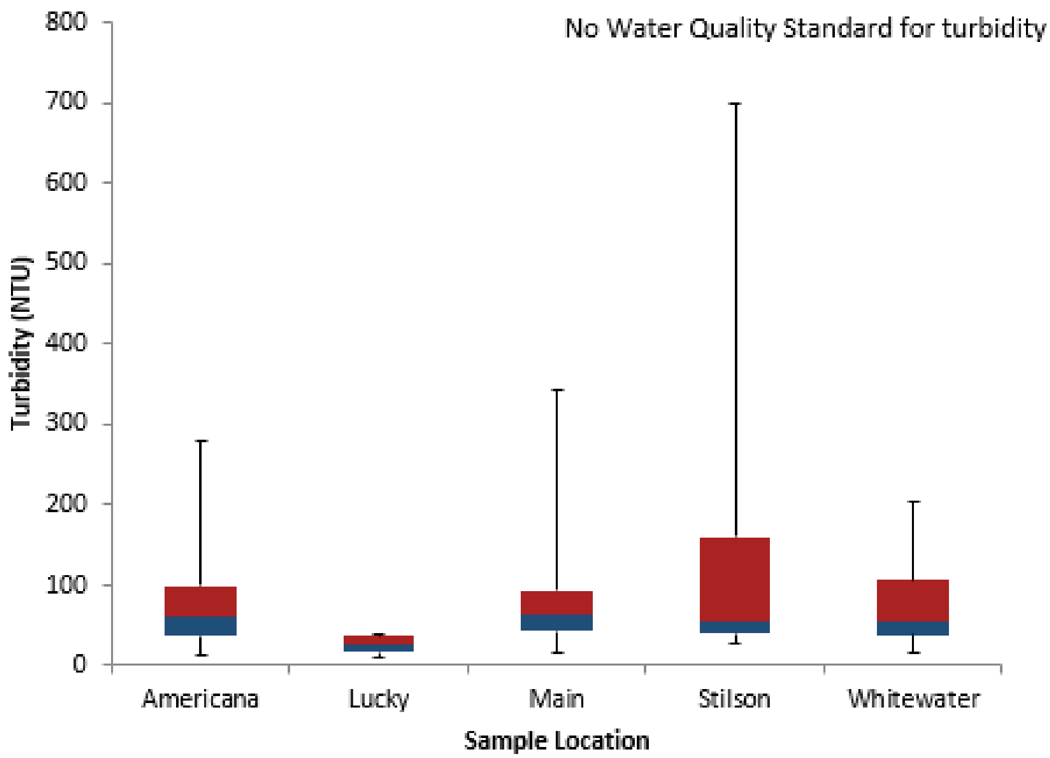

Figure 9. Turbidity measurements at all sites for 2013–2017

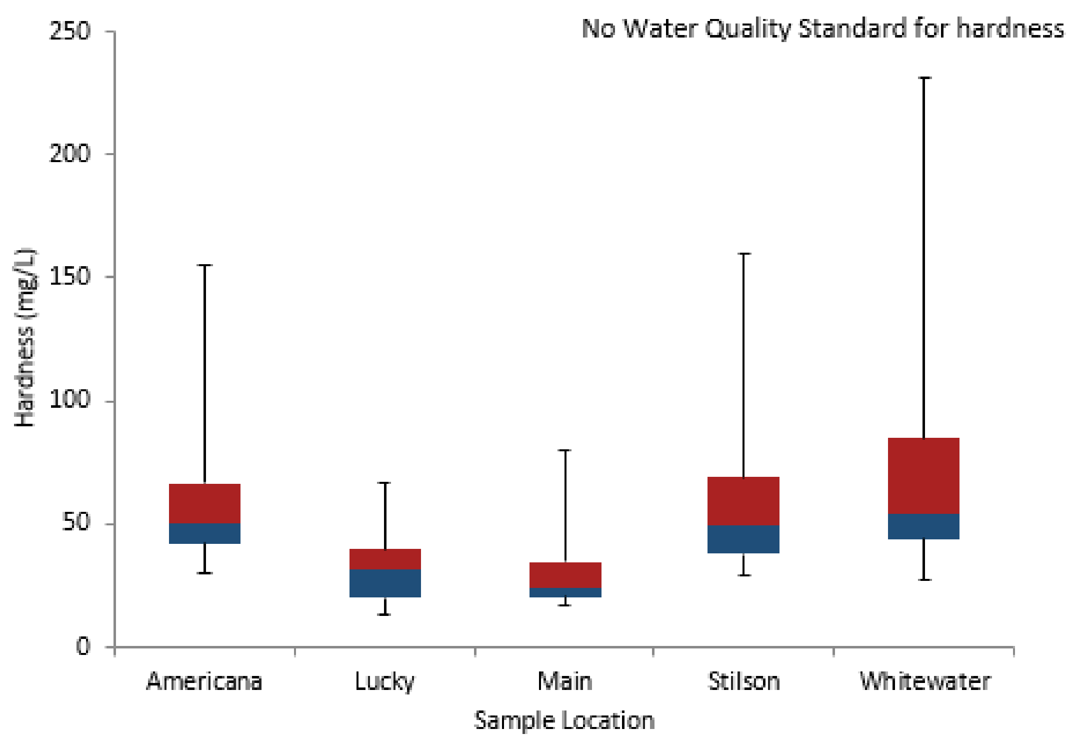

Figure 10. Hardness measurements at all sites for 2013–2017

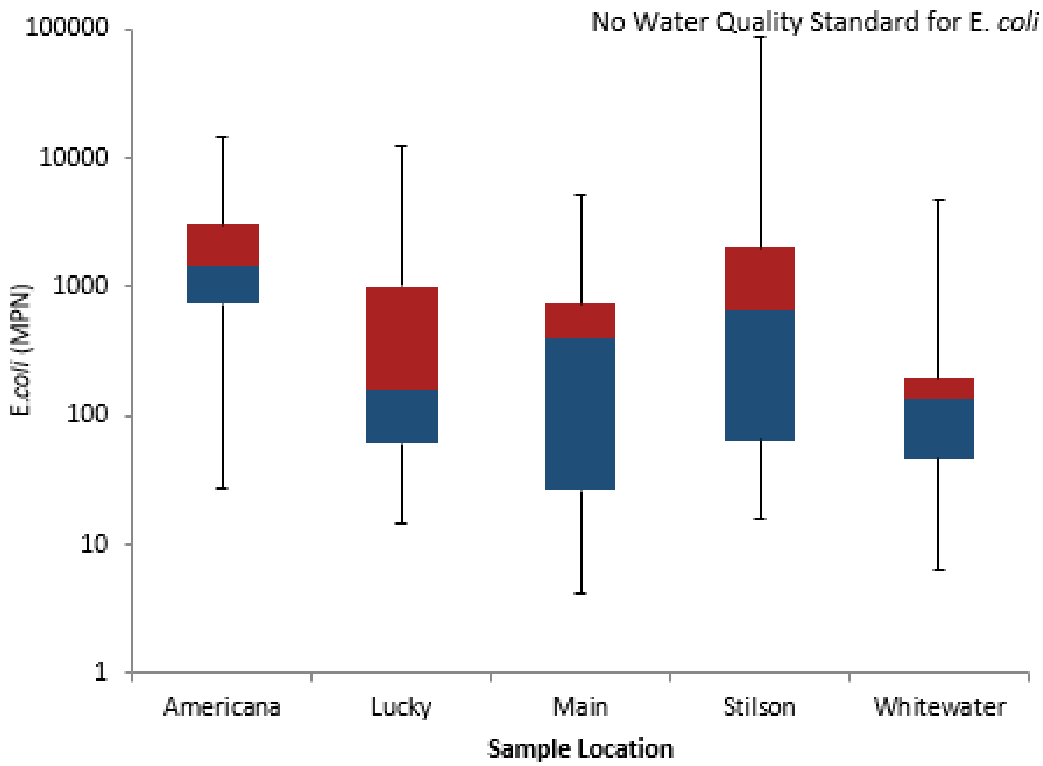

Figure 11. *E. coli* measurements at all sites for 2013–2017

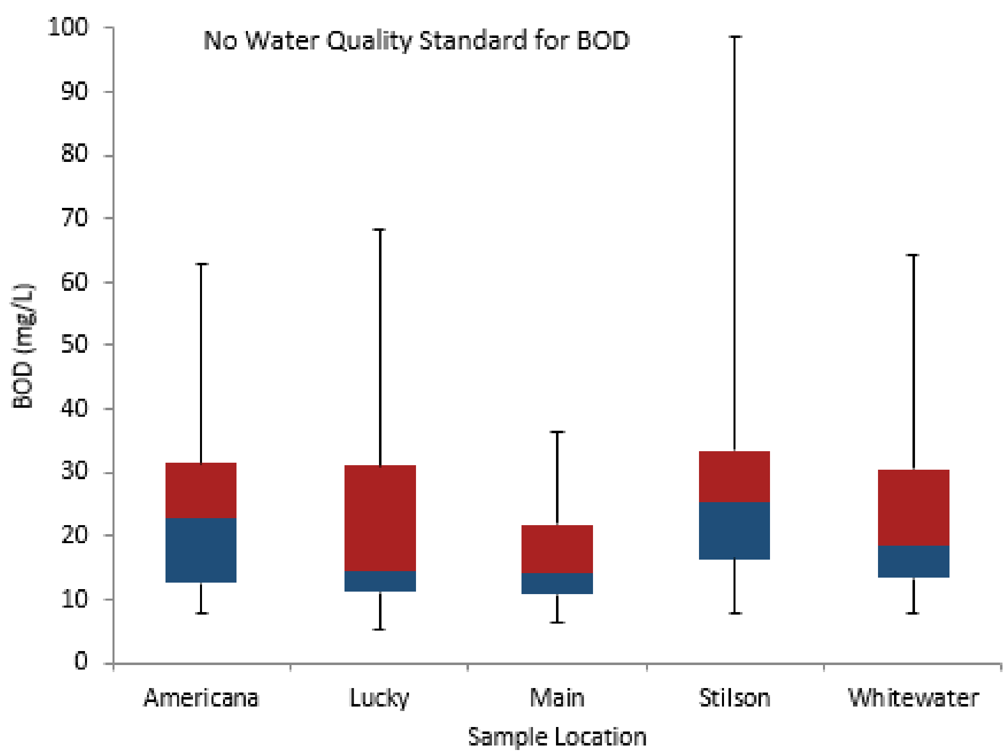

Figure 12. Biological oxygen demand (5-day) measurements at all sites for 2013–2017

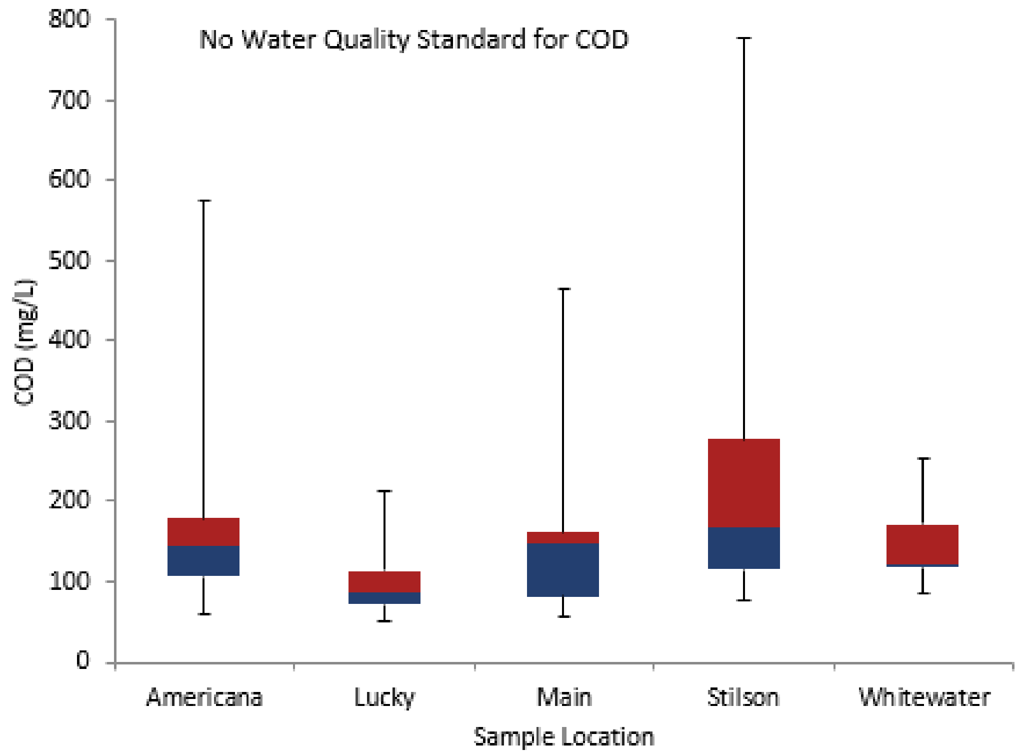

Figure 13. Chemical oxygen demand measurements at all sites for 2013–2017

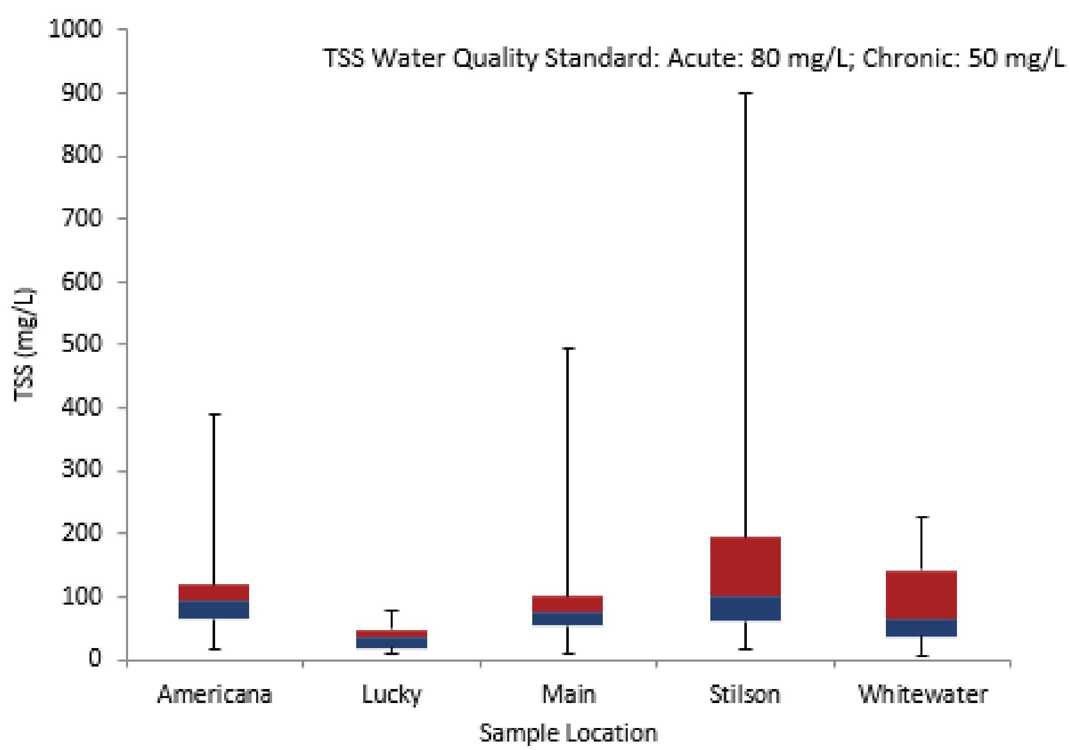

Figure 14. Total suspended solids measurements at all sites for 2013–2017

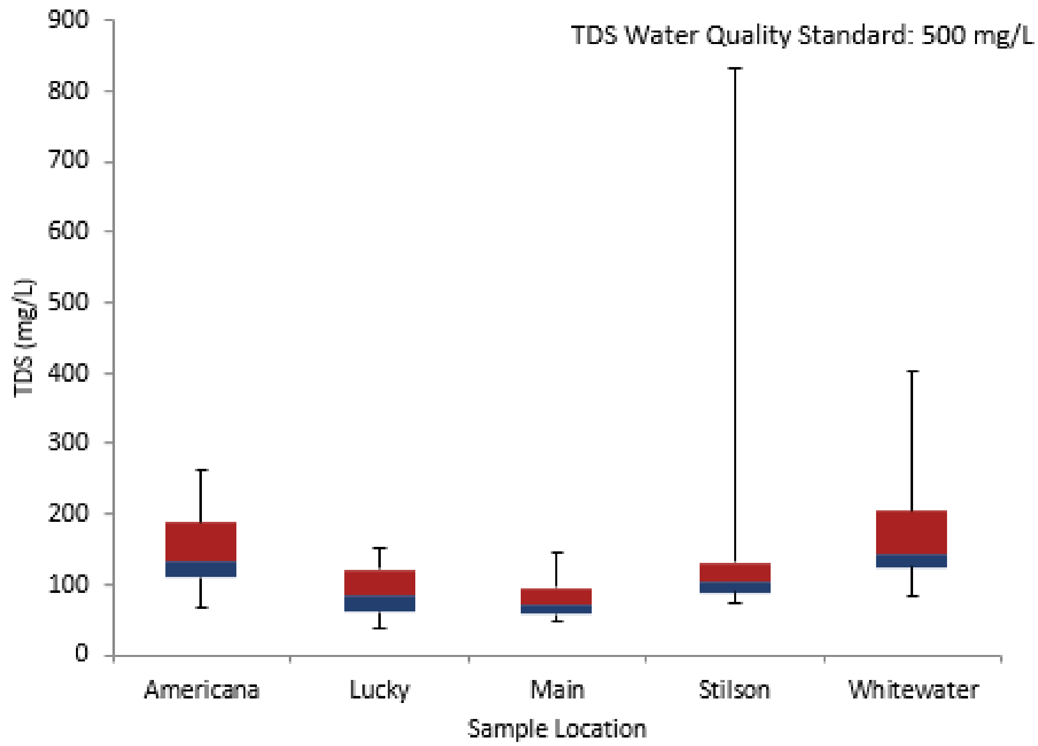

Figure 15. Total dissolved solids measurements at all sites for 2013–2017

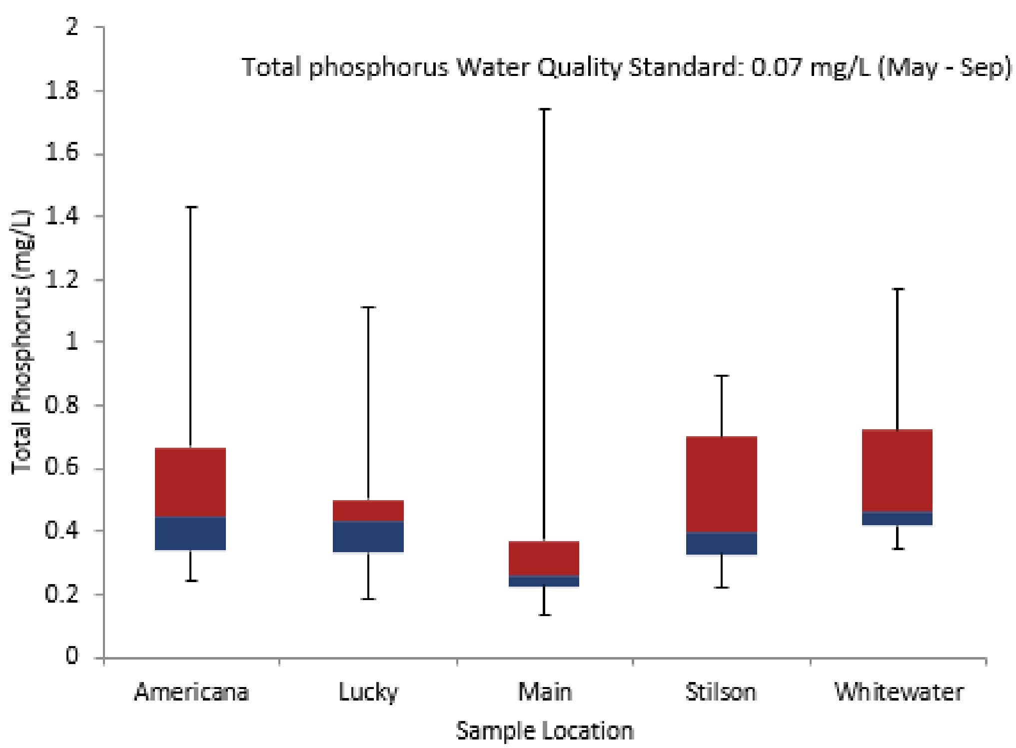

Figure 16. Total phosphorus measurements at all sites for 2013–2017

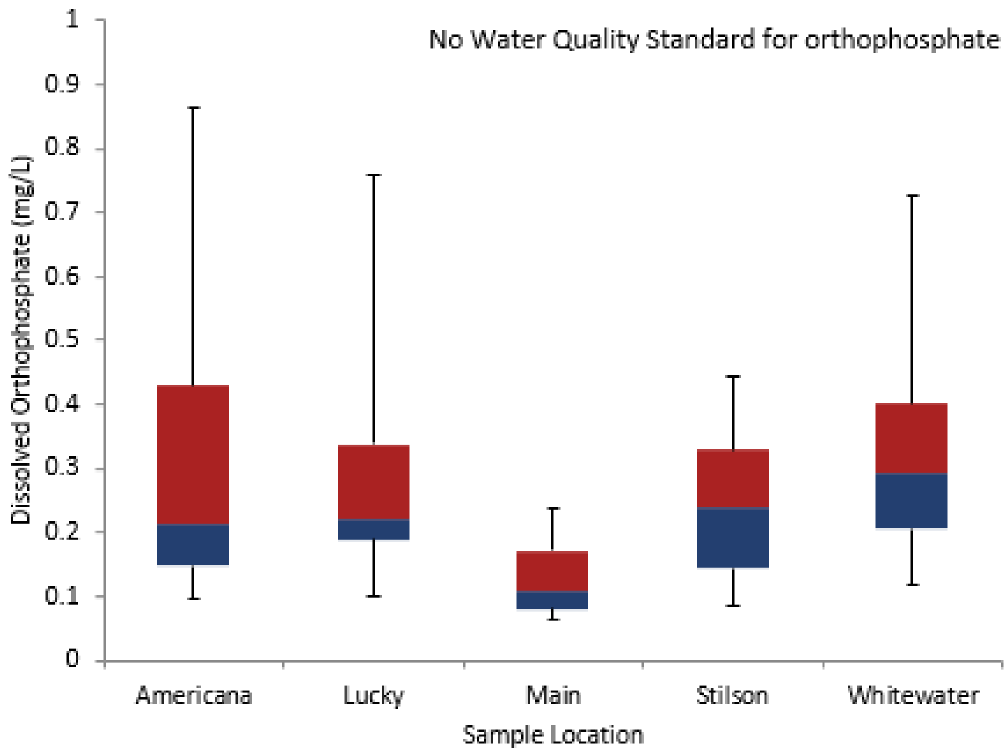

Figure 17. Dissolved orthophosphate measurements at all sites for 2013–2017

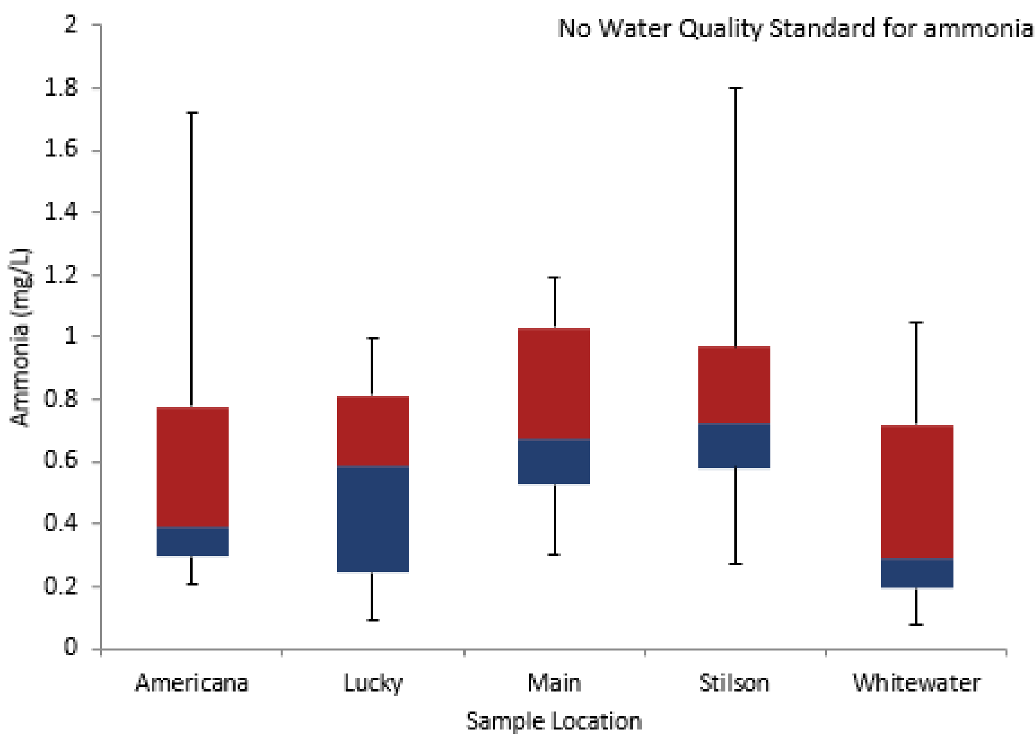

Figure 18. Ammonia measurements at all sites for 2013–2017

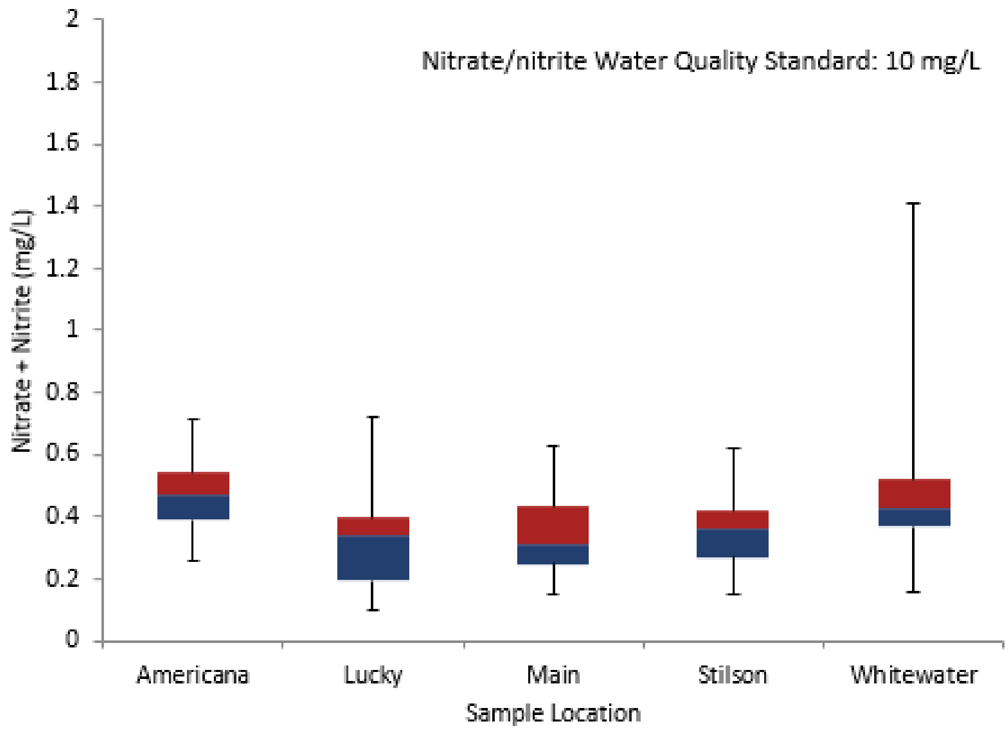

Figure 19. Nitrate + nitrite measurements at all sites for 2013–2017

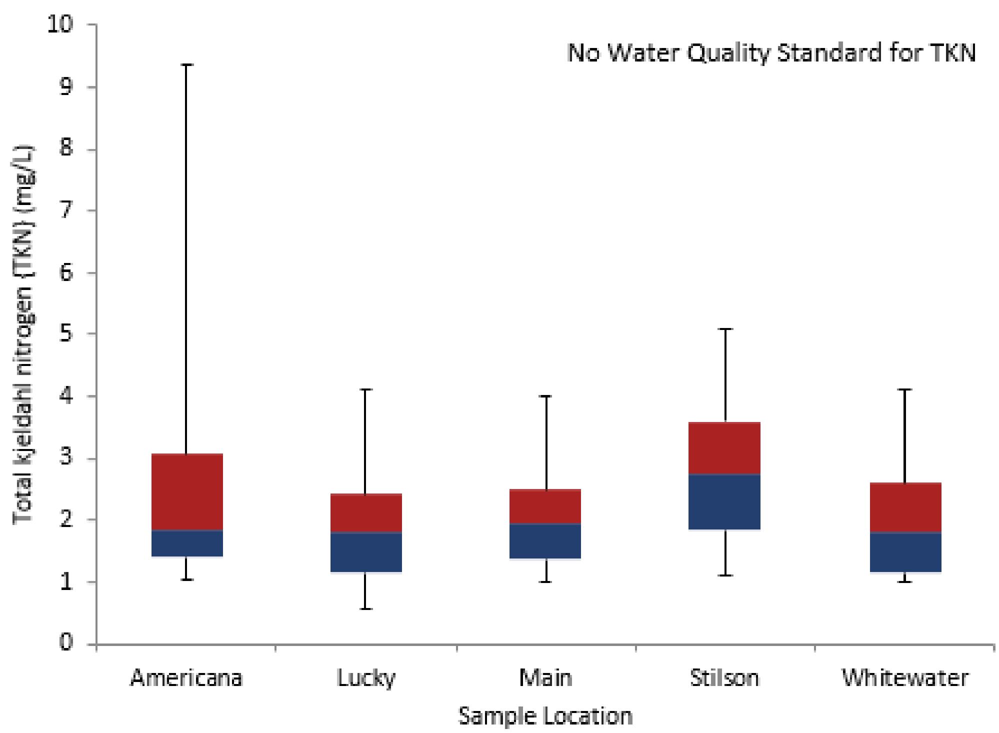

Figure 20. Total Kjeldahl nitrogen measurements at all sites for 2013–2017

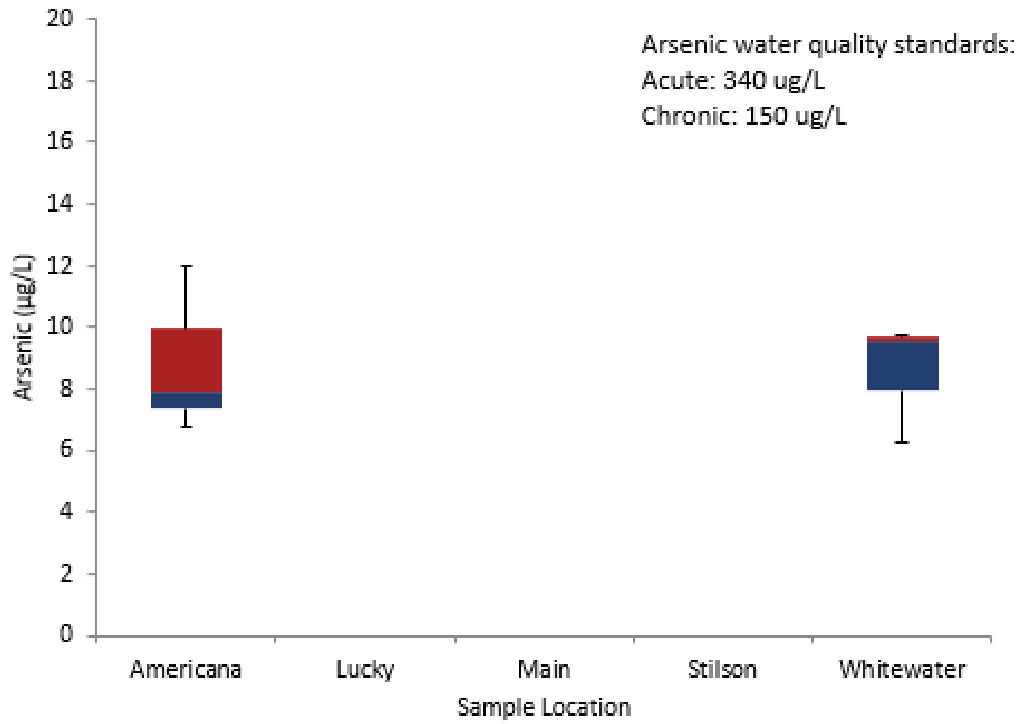

Figure 21. Total arsenic measurements at all sites for 2013–2017 (no findings for Lucky, Main, or Stilson)

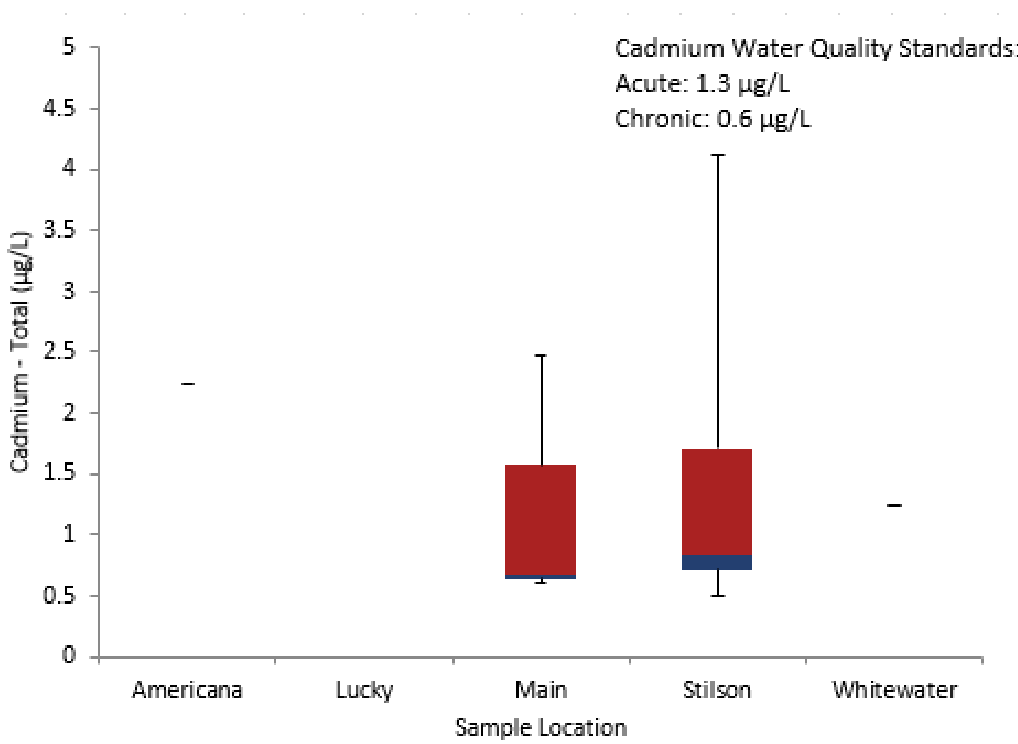

Figure 22. Total cadmium measurements at all sites for 2013–2017
(no findings for Americana, Lucky, or Whitewater)

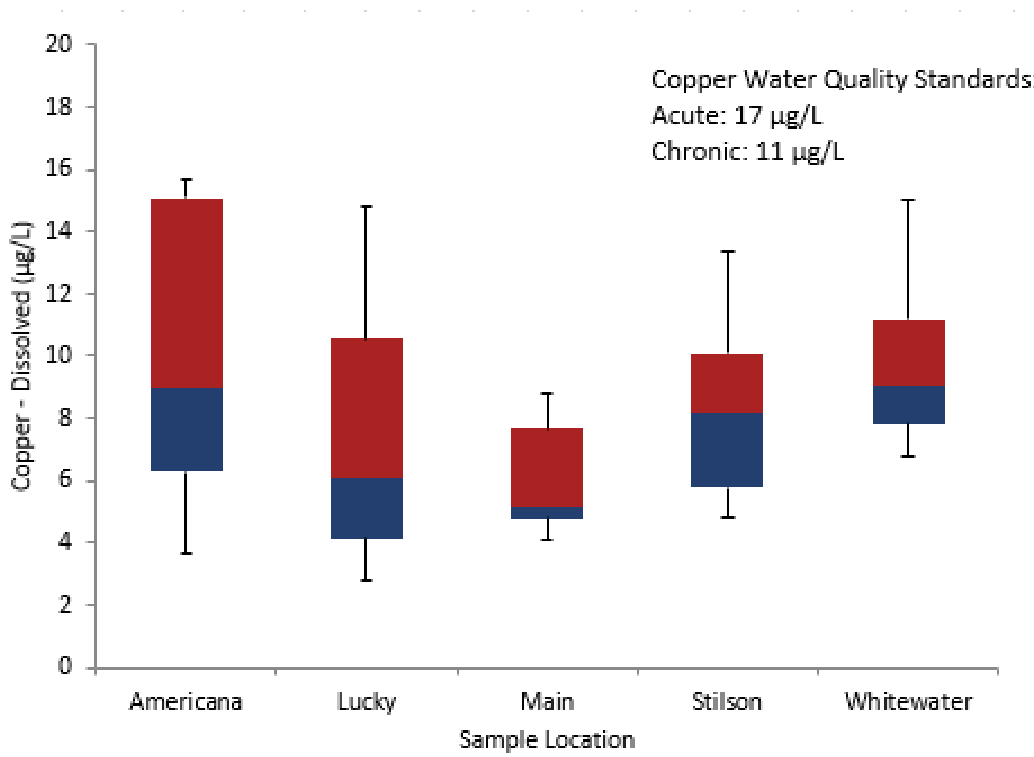

Figure 23. Dissolved copper measurements at all sites for 2013–2017

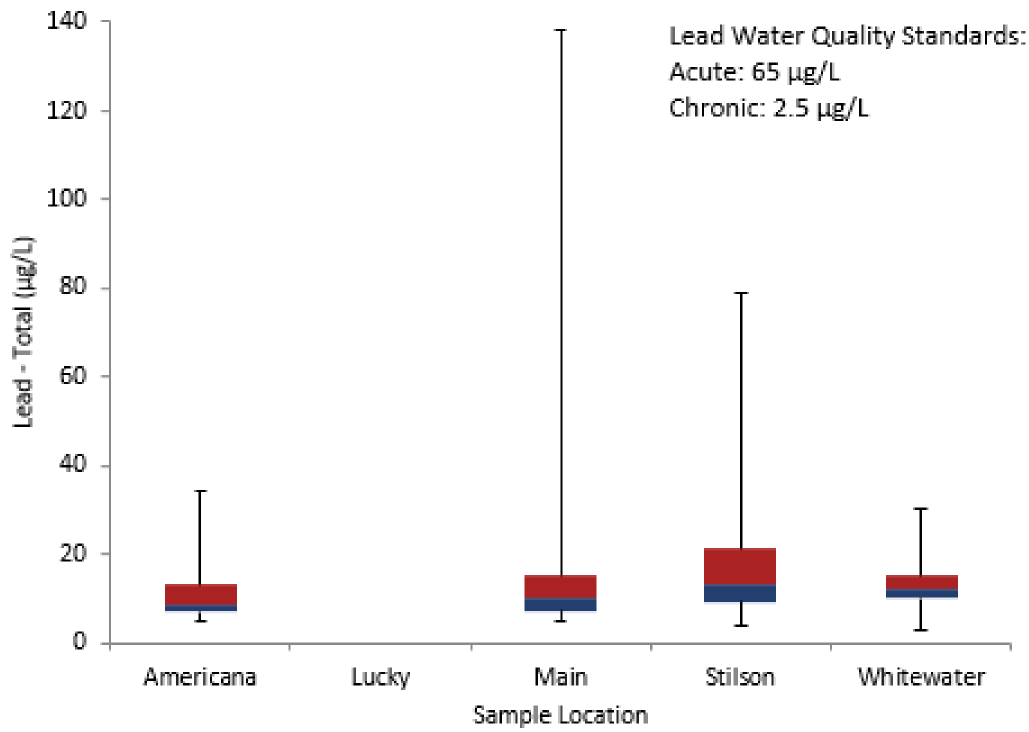

Figure 24. Total lead measurements at all sites for 2013–2017 (no findings for Lucky)

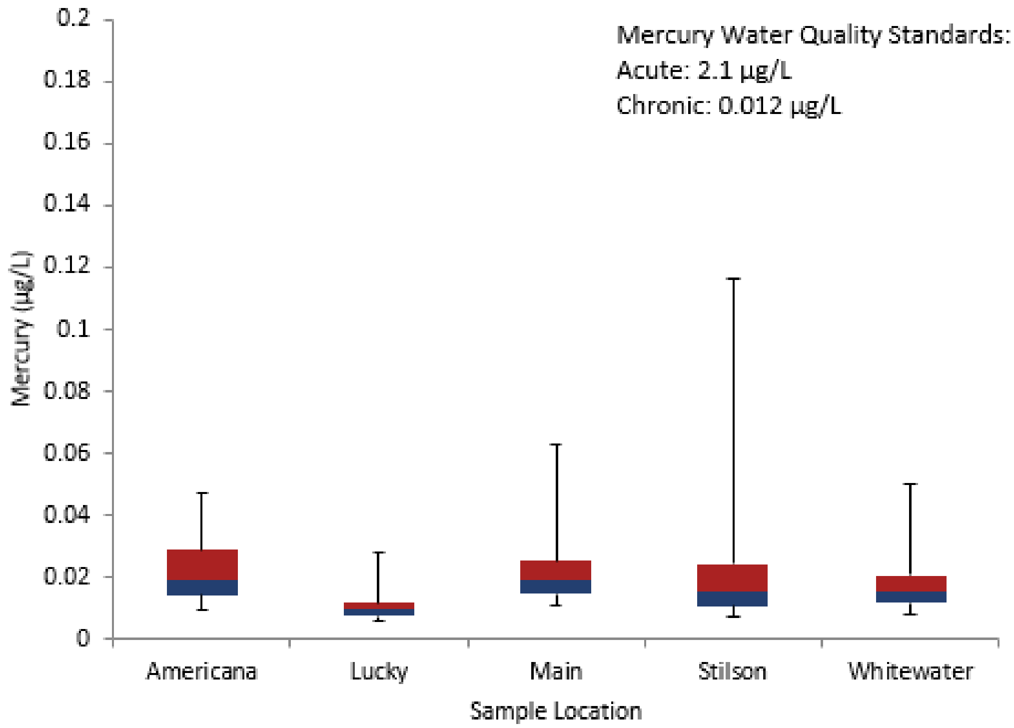

Figure 25. Total mercury measurements at all sites for 2013–2017

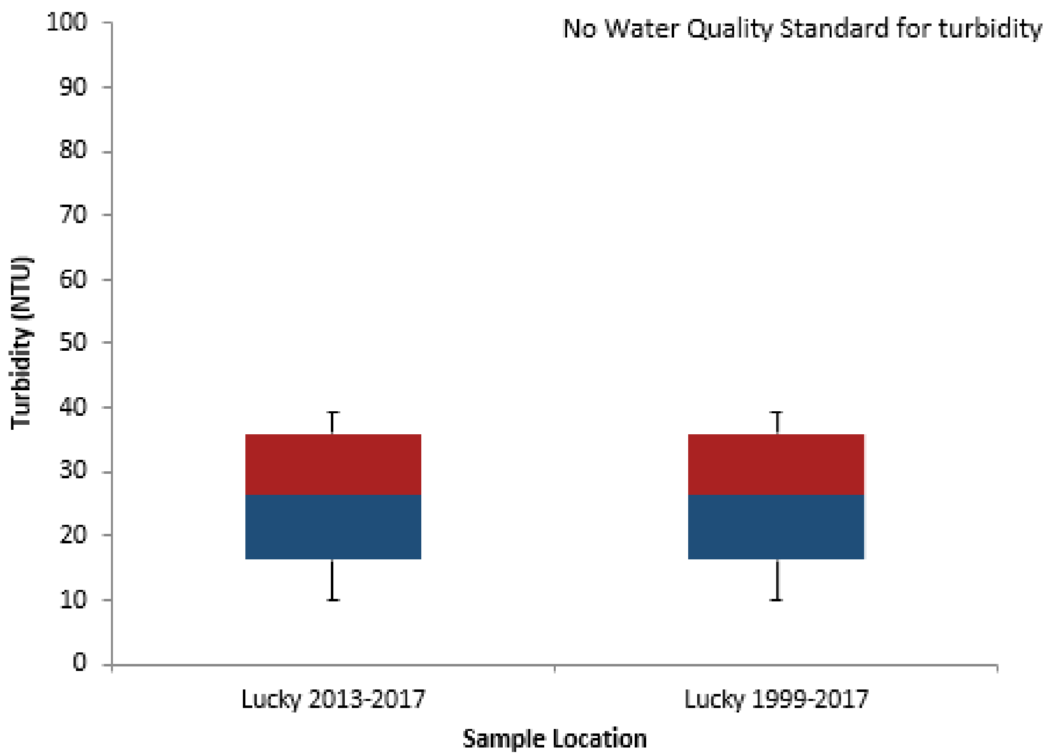

Figure 26. Turbidity measurements at Lucky for 2013–2017 and 1999–2017

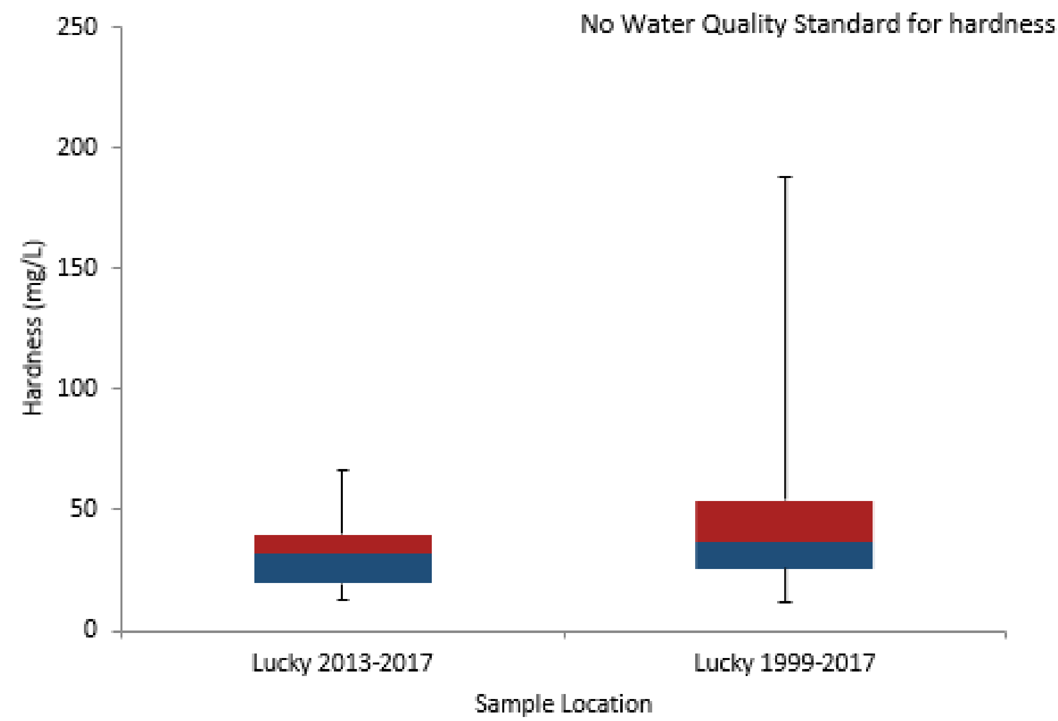

Figure 27. Hardness measurements at Lucky for 2013–2017 and 1999–2017

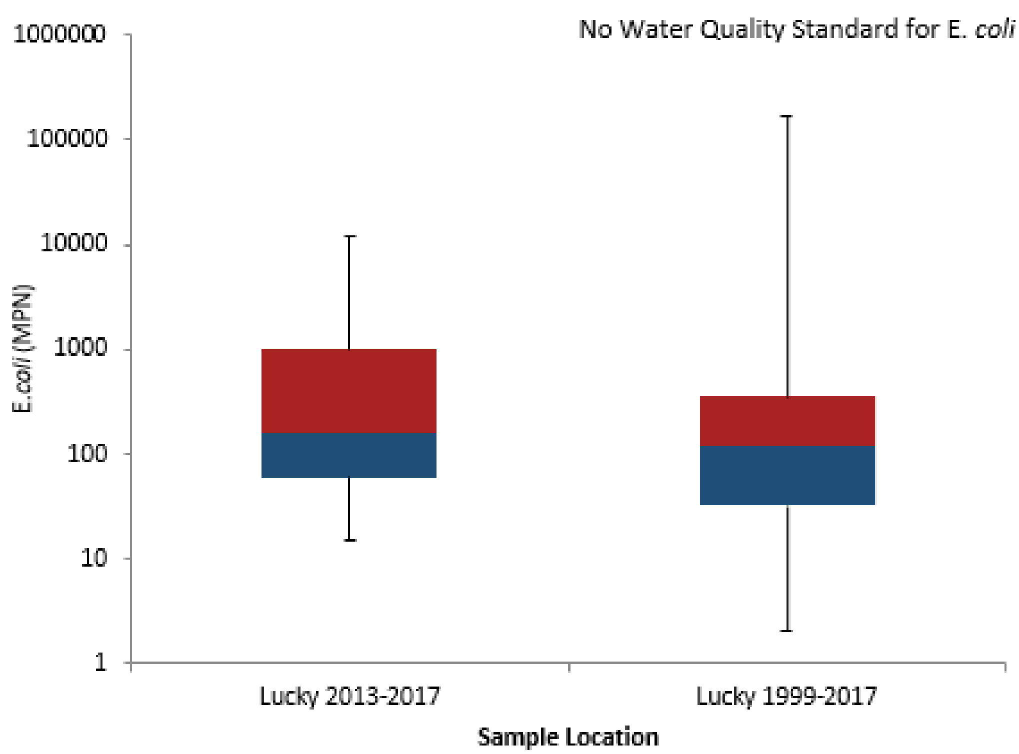

Figure 28. E. *coli* measurements at Lucky for 2013–2017 and 1999–2017

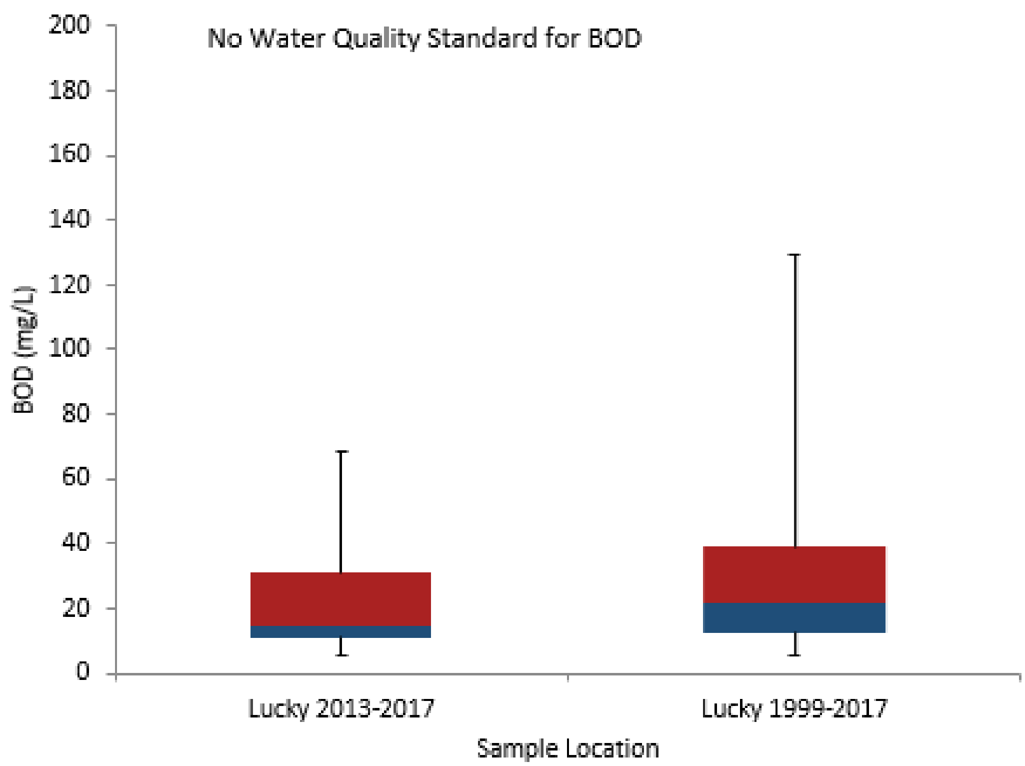

Figure 29. Biological oxygen demand (5-day) measurements at Lucky for 2013–2017 and 1999–2017

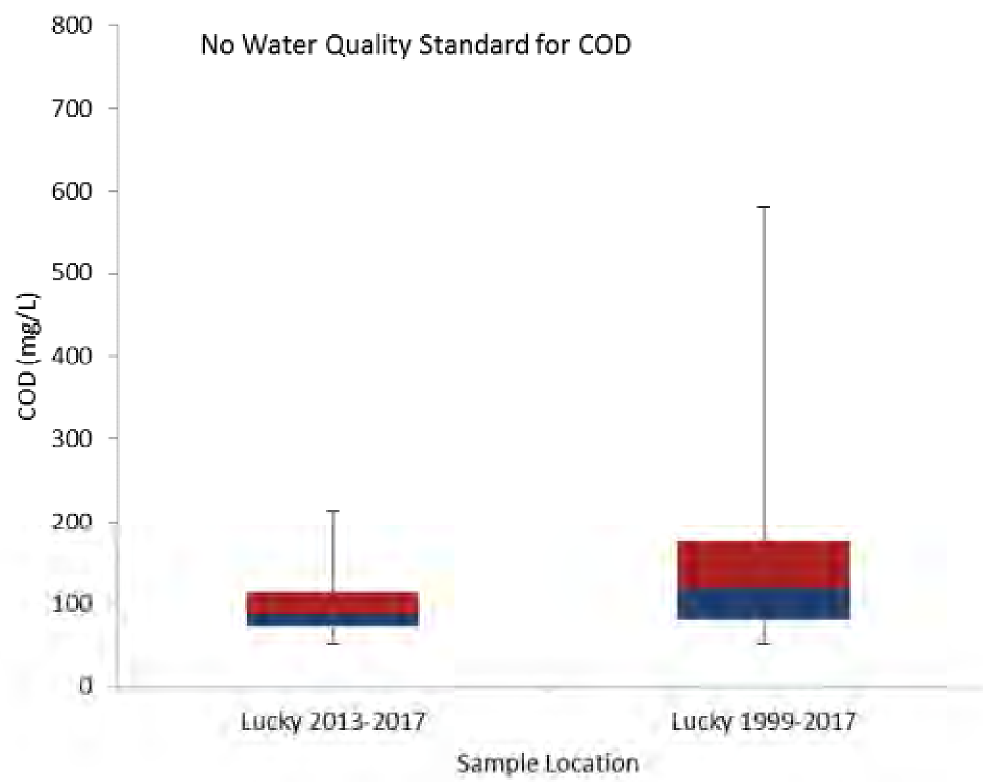

Figure 30. Chemical oxygen demand measurements at Lucky for 2013–2017 and 1999–2017

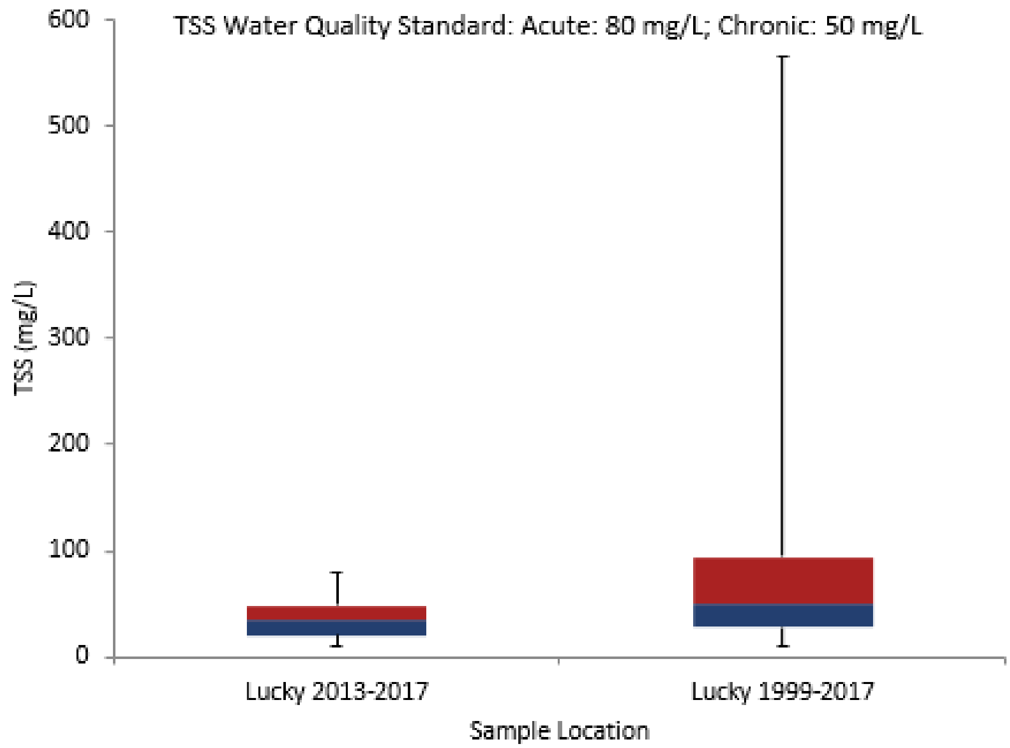

Figure 31. Total suspended solids measurements at Lucky for 2013–2017 and 1999–2017

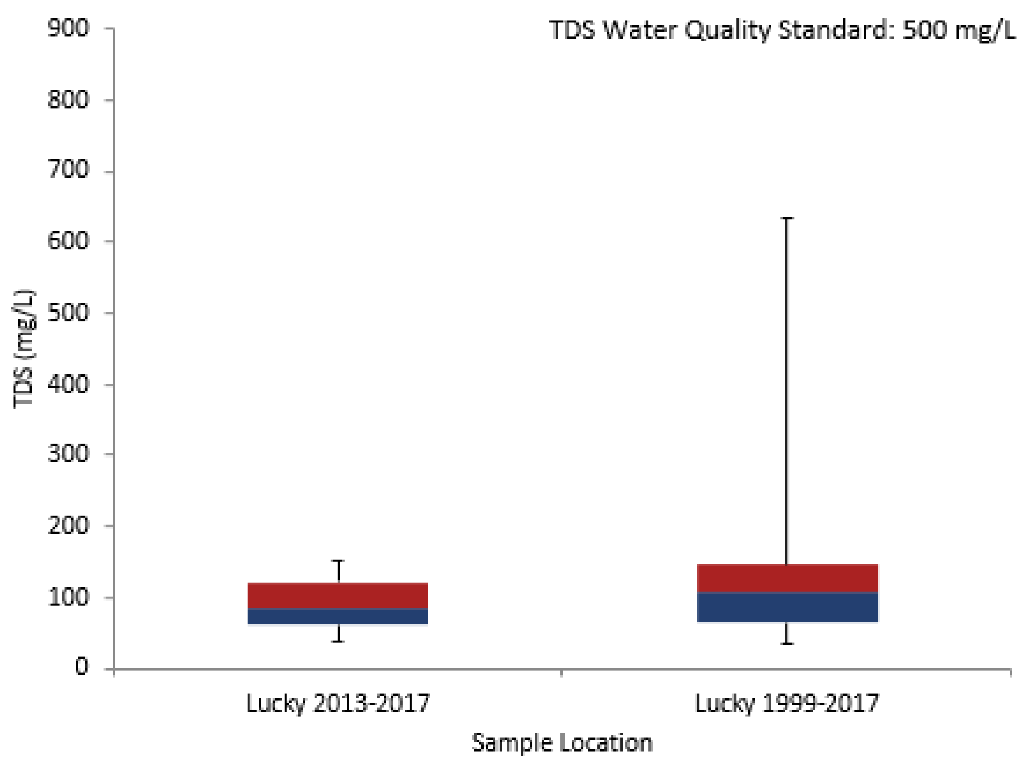

Figure 32. Total dissolved solids measurements at Lucky for 2013–2017 and 1999–2017

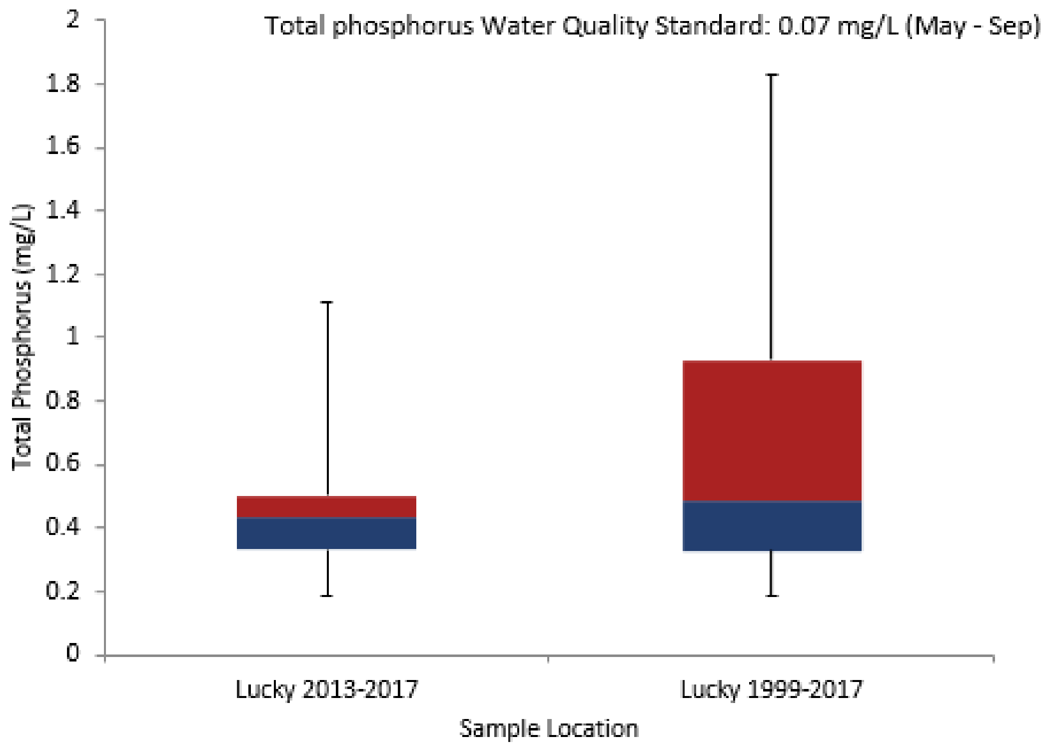

Figure 33. Total phosphorus measurements at Lucky for 2013–2017 and 1999–2017

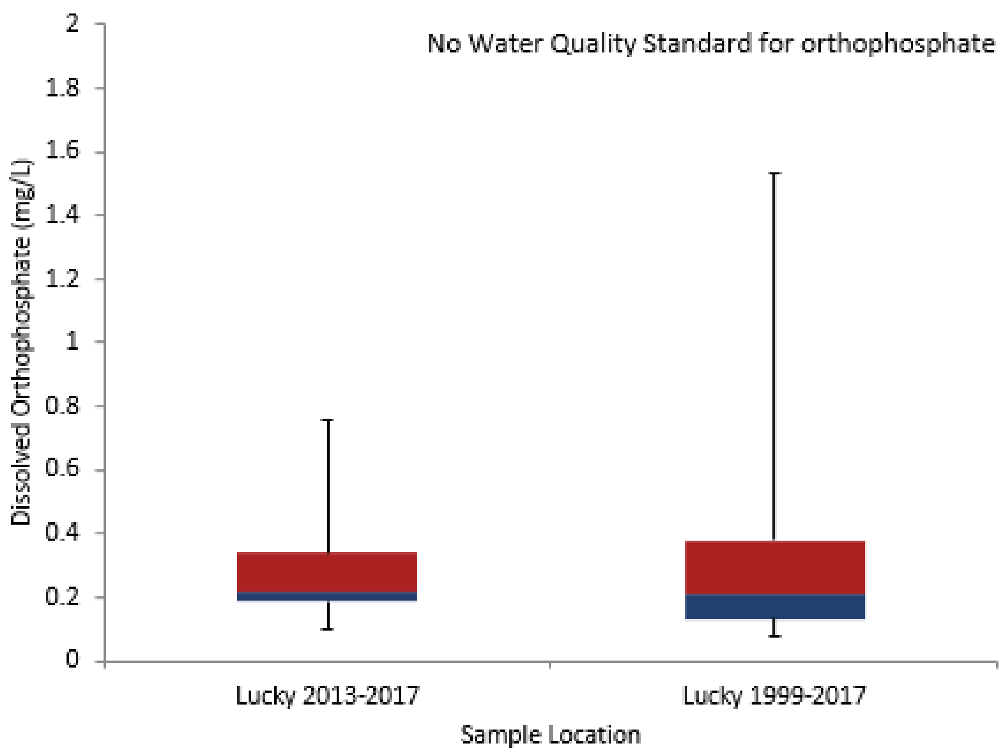

Figure 34. Dissolved orthophosphate measurements at Lucky for 2013–2017 and 1999–2017

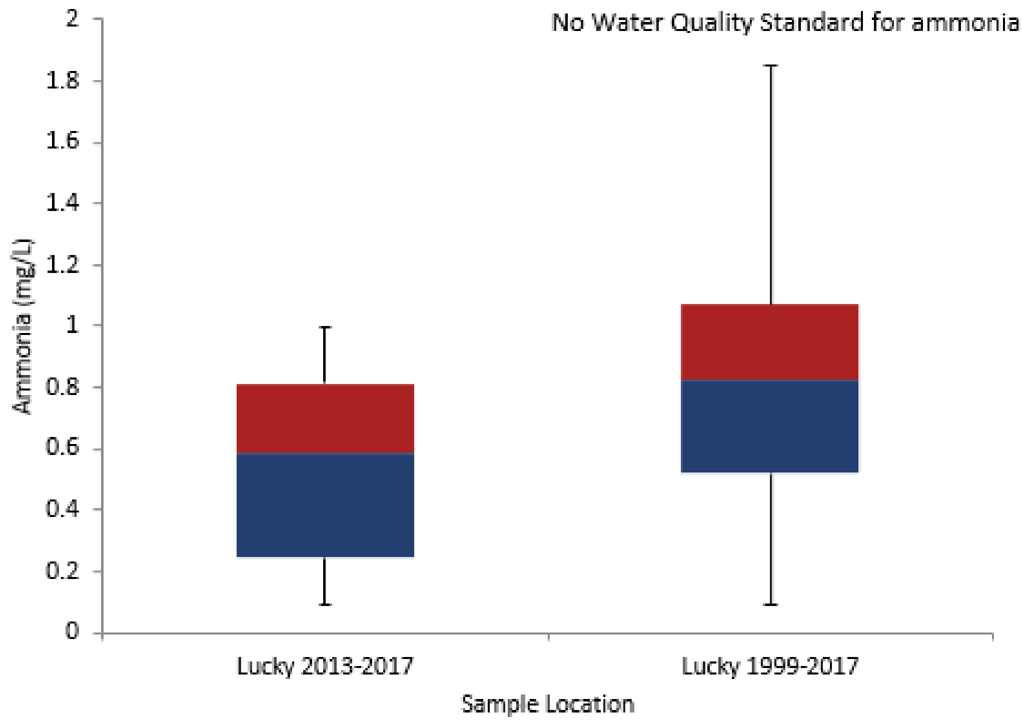

Figure 35. Ammonia measurements at Lucky for 2013–2017 and 1999–2017

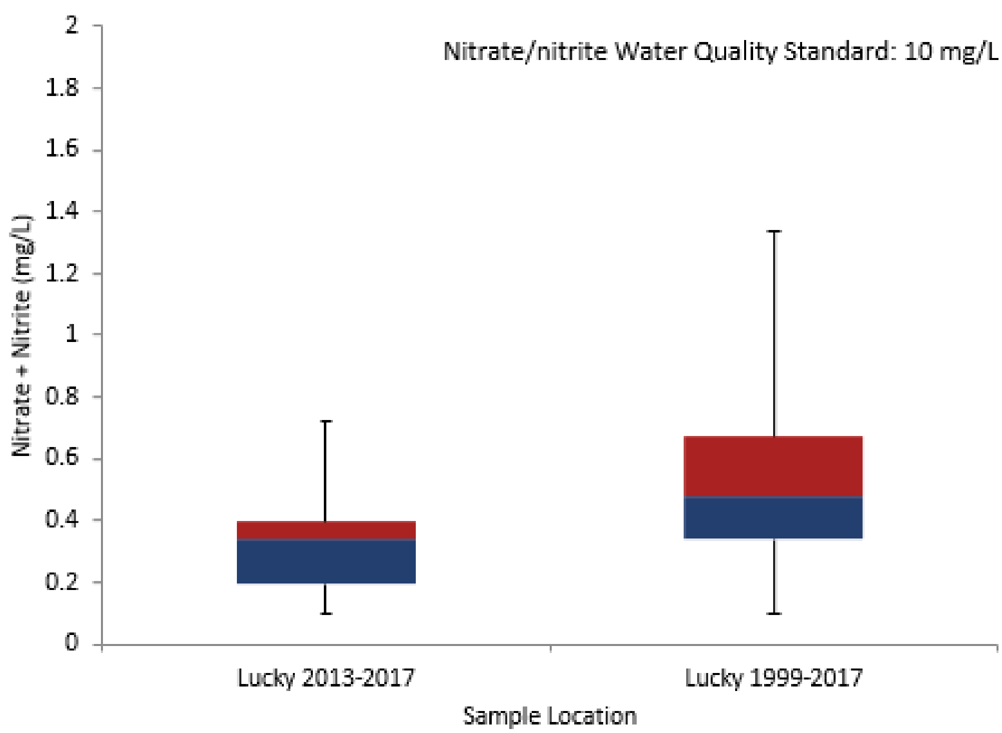

Figure 36. Nitrate + nitrite measurements at Lucky for 2013–2017 and 1999–2017

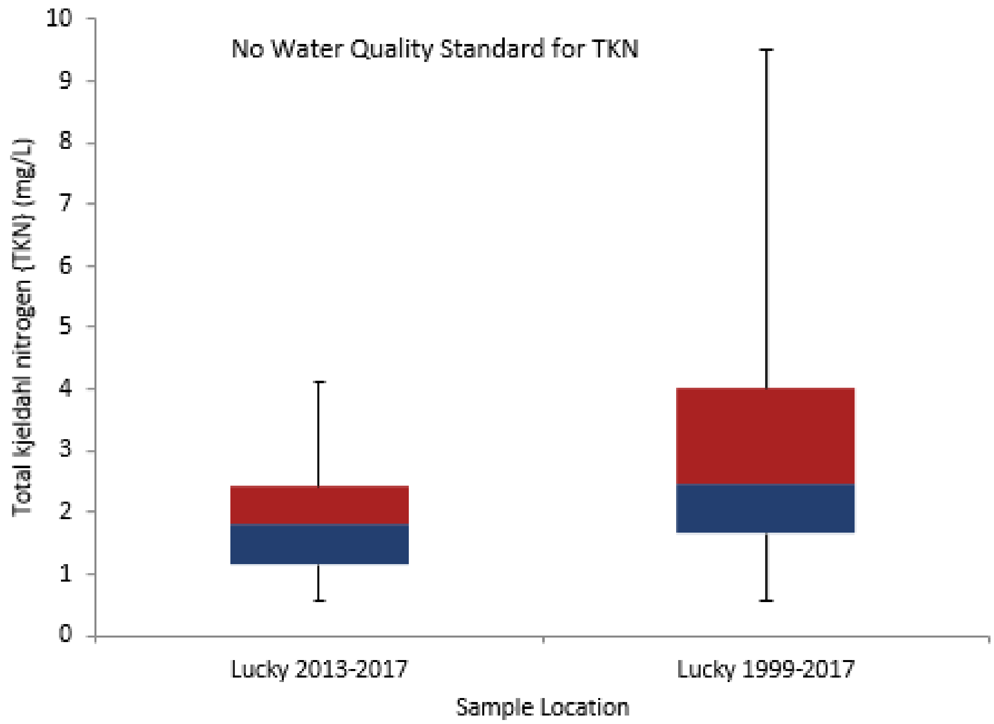

Figure 37. Total Kjeldahl nitrogen measurements at Lucky for 2013–2017 and 1999–2017

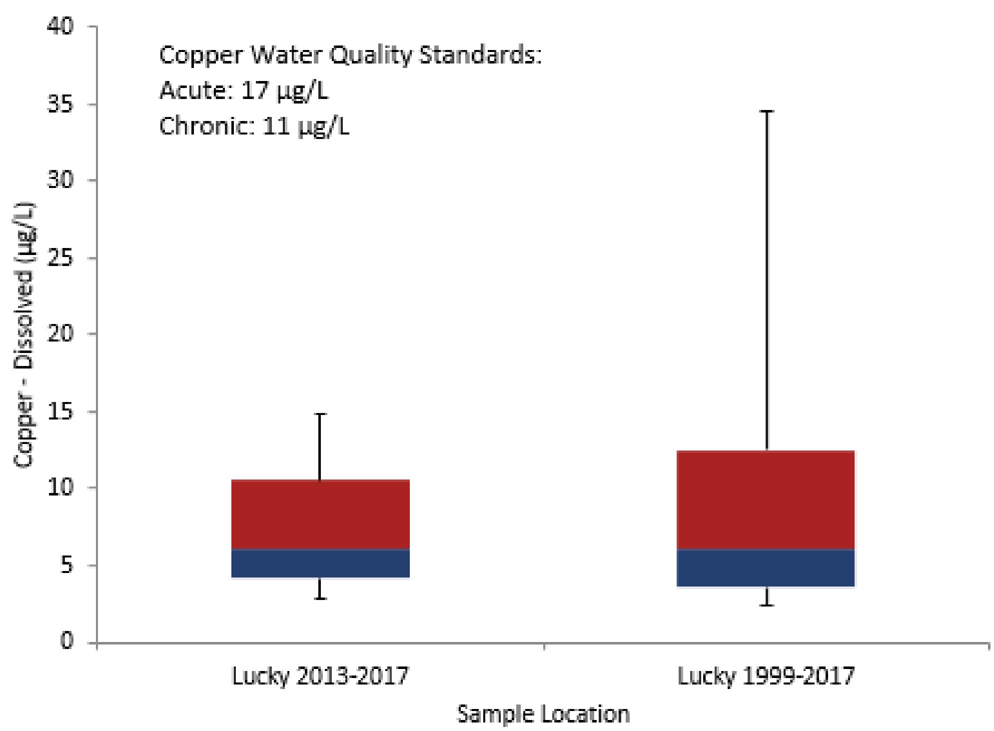

Figure 38. Dissolve copper measurements at Lucky for 2013–2017 and 1999–2017

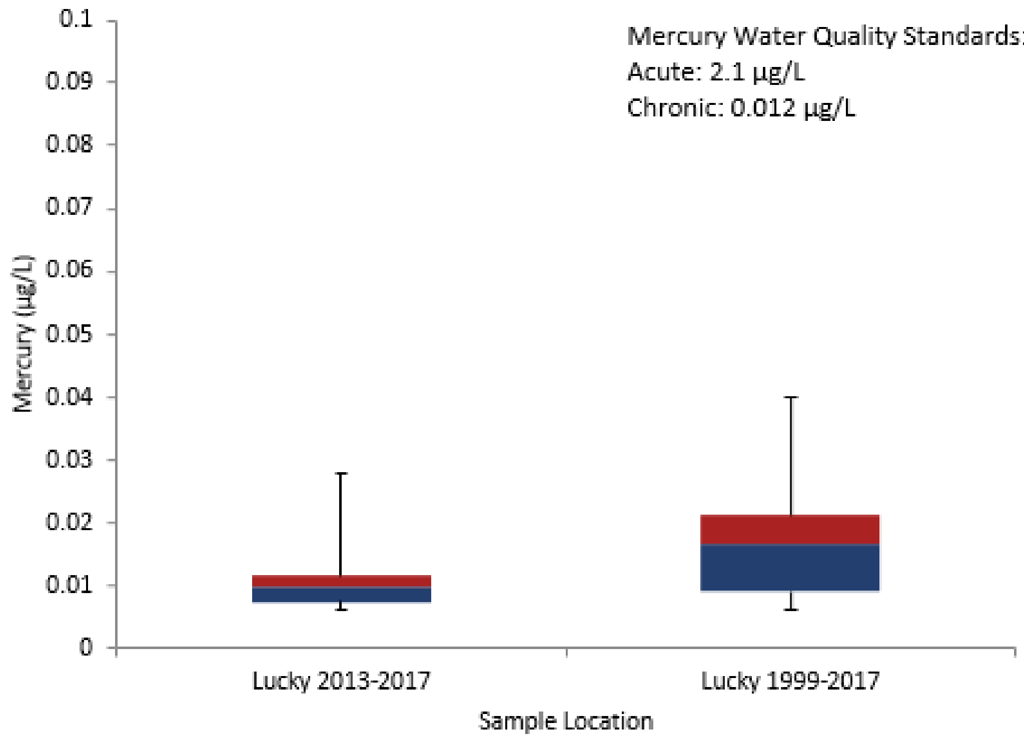

Figure 39. Total mercury measurements at Lucky for 2013–2017 and 1999–2017

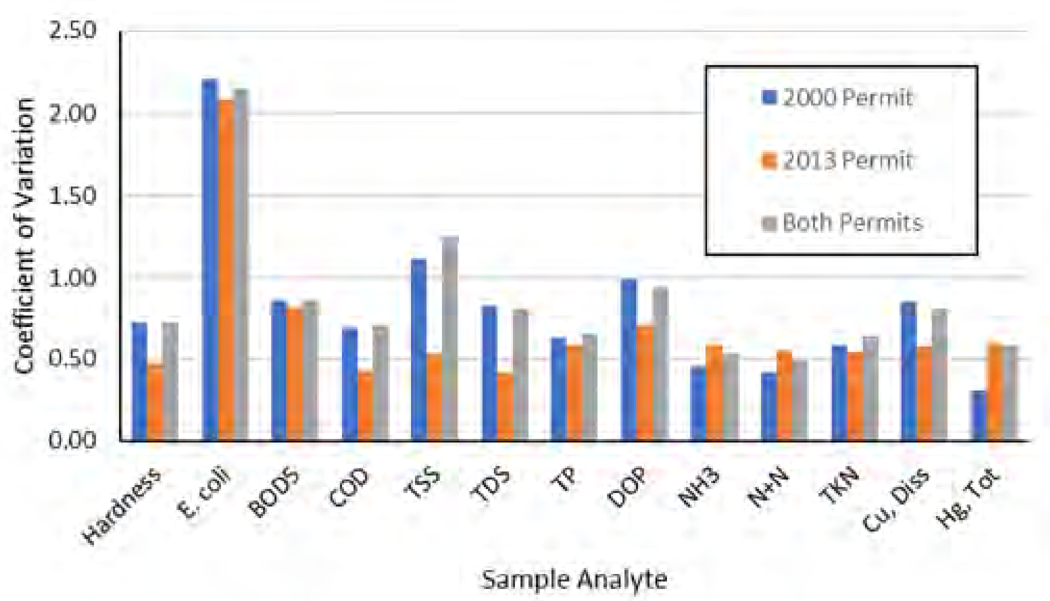

Figure 40. Coefficient of Variation in Sample Results from Lucky by Permit