City of Bend Utilities Public Advisory Group

CITY OF BEND

Location: **Hybrid Meeting**

In-person: City of Bend Utilities Department, Deschutes Conference Room, 62975 Boyd Acres Road

Online: **Microsoft Teams Meeting Link**

Date: October 2, 2024

Time: 11am-12:30pm

Speakers: Lori Faha, City of Bend Environmental Resources Manager
Elisabeth O'Keefe, City of Bend Stormwater Program Manager
Austin Somhegyi, City of Bend Stormwater Master Plan Project Manager
Trista Kobluskie, Stormwater Master Plan Consultant Team Lead
Anna Murphy and Daniele Spirandelli, Stormwater Master Plan Consultant Team
Aubrie Koenig, Facilitator

Meeting Agenda

Purpose: Discuss and collect input on potential climate-related recommendations in Stormwater Master Plan and share master plan progress updates and stormwater program regulatory updates.

1. **Introduction** – *5 mins*
2. **Stormwater Master Plan and Climate Change** – *25 mins*
    a. Discuss level of planning for climate change
    b. Discussion question:
        i. *Do you think there is a need for climate-related policy or program recommendations in the Stormwater Master Plan?*
3. **Stormwater Master Plan Updates** – *25 mins*
    a. Share updated draft CIP prioritization criteria (see matrix)
    b. Summarize drillhole and outfall prioritization approach (see memos)
    c. Discussion questions:
        i. *How quickly should the City address the 17 high priority drillholes? 5 years? 10 years? 20 years?*
        ii. *Does the outfall prioritization approach make sense to you?*

4. **Stormwater Program Regulatory Updates** – *20 mins*
    a. Discuss erosion control requirements for small construction sites
    b. Share next steps to update UIC standards for groundwater protectiveness
    c. Discussion questions:
        i. *Is the draft guidance and resources for small developers understandable?*
        ii. *Are there any guidance areas that may require more support?*
5. **UPAG Discussion** – *10 mins*
6. **Summary and Closing** – *5 mins*

UPAG Meeting Roadmap *draft*

CITY OF BEND

November 6, 2024 11am-12:30pm Hybrid: in-person at City Boyd Acres site or virtual on Teams	**NOV 2024 UPAG MEETING: Water Conservation Program** • Discuss turf rebate pilot year results and planning for next year • Discuss scope for program effectiveness review • Get input on communications campaign development ***Outcome:*** *Input on water conservation program planning for 2025.*
December 4, 2024 11am-12:30pm Hybrid: in-person at City Boyd Acres site or virtual on Teams	**DEC 2024 UPAG MEETING: Stormwater Master Plan & Annual Review** • **Stormwater Master Plan:** summarize results of CIP prioritization • **Annual Review:** introduce new members, review 2024 highlights and how UPAG advice is being used, preview 2025 topics and input areas ***Outcome:*** *Welcome new members and refine meeting roadmap for 2025.*
January 8, 2025 11am-12:30pm Hybrid: in-person at City Boyd Acres site or virtual on Teams	**JAN 2025 UPAG MEETING: Stormwater Master Plan Policy Topics** • Discuss strategies to address drainage and development density • Review and discuss level of service for stormwater management ***Outcome:*** *Input on potential policy solutions in master plan.*

Accessible Meeting Information

This meeting/event location is accessible. Sign language interpreter service, assistive listening devices, materials in alternate format such as Braille, large print, electronic formats, or any other accommodations are available upon advance request. Please contact Lori Faha at lfaha@bendoregon.gov or (541) 317-3025; Relay Users Dial 7-1-1. Providing, at least, 3 days' notice prior to the event will help ensure availability.

Bend Stormwater Master Plan
CIP Rating Criteria Revised - UPAG Discussion
9/18/24 ***Max Pts Avail. 80.00***

Weight	High Score	Max Total	Criterion	Description	Scoring Concept	Discussion Notes [Bold notes denote changes since 9/4 UPAG meeting]
1. Conveyance & Flooding						
2.00	5	10.00	Frequency of Flooding Event	Does the project reduce flooding and if yes, for flooding at what frequency?	Projects that address more frequent floods receive more points.	**Weight increased from 1.0 to 2.0**
2.00	5	10.00	Flooding Severity/Risk Avoidance	What types of properties or assets will be protected from flooding under this project? What risks to the traveling public will be avoided under this project?	Projects that address flooding that damages private property or has serious traffic impacts receive more points.	**Weight increased from 1.0 to 2.0**
Max points		**20.00**				
2. Water Quality Improvements						
3.00	5	15.00	River & Groundwater Protection	Did the drill hole or outfall rate highly in a needs analysis to identify UICs or outfalls that are most in need and best suited to water quality retrofit?	Projects that address already-prioritized drillholes and outfalls receive more points.	UPAG indicated that protecting groundwater and protecting the Deschutes are top priorities.
1.00	5	5.00	Permit Compliance	Does the project assist in meeting WPCF or MS4 Permit requirements?	Projects that assist in meeting WPCF or MS4 Permit requirements receive more points.	
Max points		**20.00**				
3. Multiple Benefits						
1.00	5	5.00	Increases Equitable Distribution of Public Stormwater Assets	Does the project provide drainage and stormwater management where public storm system is lacking OR does the project serve a location with a traditionally underserved population identified by City of Bend?	Projects that are located where City storm system is not present and that will serve populations living below the federal poverty level (by Census Block Group) or have a relatively high minority populations receive more points.	**Exact scoring criteria and terminology will be further discussed with Bend Long Range Planning.** The definitions and extents of these areas are under discussion. **[Weight increased from 0.75 to 1.0]**
1.00	5	5.00	Supports Housing or Economic Development	Does the project support urban renewal or production of middle or affordable housing?	Projects receive maximum points if they are located at the intersection of 3 types of City focus areas listed here; points reduce with fewer types of focus areas: - Urban Renewal District - Economic Improvement District - Enterprise Zone - Opportunity Area	**Exact scoring criteria and terminology will be further discussed with Bend Long Range Planning.**
0.50	5	2.50	Maintenance Safety/Access	Does the project improve the ease of maintenance and/or safety of staff during maintenance?	Projects receive either maximum points or no points.	
0.50	5	2.50	Green Infrastructure / Ecosystem Services	Several criteria in this decision-support tool benefit ecosystem services, such as protection of surface water and groundwater resources. Additional ecosystem services may be offered by Green Infrastructure, such as vegetation and aesthetics.	Projects that are likley to include an above-ground component that is vegetated, including swales, ponds, LID planters, stormwater trees, tree canopy, and riverbank restoration (not including replacement of vegetation disturbed by the project) receive maximum points.	**New criterion**
0.50	5	2.50	System Longevity	Does the project rehabilitate an existing asset or improve the function or longevity of an existing asset?	Projects receive either maximum points or no points.	UPAG indicated equal priority with extending the lives of current facilities and building new facilities. Other programmatic solutions may also address repair/replacement of existing infrastructure.
0.50	5	2.50	Community Partnerships	Will the project be developed in partnership with an organization such as Bend Park and Recreation District or Upper Deschutes Watershed Council?	Projects receive either maximum points or no points.	
0.00	5	0.00	Synergy	Is it a "Synergy" project?	Projects receive either maximum points or no points.	**Omit this criterion per staff direction at UPAG on 9/4/24**
Max points		**20.00**				
4. Recognized Priority Projects						
2.00	5	10.00	Staff Priority	Is the project an agreed priority for City staff?	Points are awarded based on City Utilities Operations staff priorities (1-3). One point is available for Engineering and Compliance staff priorities.	
0.00	5	0.00	UPAG Priority	Did the project received support when presented to the Utilities Public Advisory Group?	Public and UPAG priority will be applied during a later step of the planning process.	**Both UPAG and general public input on project priority will be assessed later for the implementation phase. Therefore, this criterion is omitted from the prioritization matrix. UPAG will also be given the opportunity to see which projects did not get included in the CIP after the rating criteria have been applied.**
Max points		**10.00**				
5. Feasibility & Cost						
1.00	5	5.00	Complexity / Site Constraints	Does a physical condition such as proximity to a water well, landslide, or unfractured bedrock or need to acquire significant property mean that a solution is likely higher cost than a similar project in a less complex location?	Projects receive more points when they have less complex site conditions. Site conditions may not be known when scoring. Engineering judgement and information from City staff will be used to score.	
1.00	5	5.00	Low Cost	Is the project a low-cost solution?	Projects with low initial capital costs and low ongoing maintenance costs receive maximum points. Points reduce with higher capital cost and higher ongoing maintenance cost.	We will be asking for City Utilities Operations staff input on ongoing maintenance cost of various facility types.
Max points		**10.00**				

Memorandum

To: Austin Somhegyi, City of Bend

From: Trista Kobluskie, Philip Kenyon, PE

Copies: Lori Faha, Elisabeth O'Keefe, File

Date: August 27, 2024

Subject: Outfall Retrofit Needs Assessment

Project No.: 20359

Introduction

The City of Bend is updating its Stormwater Master Plan (SMP) and is reviewing its existing stormwater outfalls to identify retrofit needs and opportunities. Stormwater in the City of Bend discharges predominantly into underground injection controls (UICs). However, the area around the Deschutes River north of Farewell Bend Park discharges to the river itself. Geographic Information System (GIS) records indicate that there are 31 outfalls owned by the City of Bend. An outfall is a point discharge from the City's Municipal Separate Storm Sewer System (MS4) into the river. A majority of these outfalls are not located on City-owned property and are located either on Bend Park and Recreation Department (BRPD) properties or located on other private properties. This Outfall Retrofit Needs Assessment studies the characteristics of each outfall's contributing basin with respect to its pollution source potential and incorporates information about the condition and accessibility of the stormwater pipes and outfalls.

Purpose

The purpose of this Outfall Retrofit Needs Assessment is to document the City's stormwater quality retrofit objectives and to identify the outfalls most in need of retrofit when considering the objectives. Subsequent analyses will identify potential projects to retrofit the highest priority outfalls. The City's MS4 permit requires the following: "The permittee must develop a Stormwater Quality Retrofit Strategy that addresses areas identified by the permittee as having an impact on water quality, and that are underserved, difficult to maintain in its current design, or lacking stormwater quality controls.

A. The stormwater retrofit strategy must be based on a permittee-defined set of stormwater quality retrofit objectives and a comprehensive evaluation of a range of retrofit control measures and its appropriate use. The permittee-defined objectives must prioritize progress toward improving water quality.

B. The permittee must submit a stormwater retrofit strategy document with permittee-defined objectives with the fourth annual report, due to the Oregon Department of Environmental Quality by November 1, 2025.

Stormwater Quality Retrofit Objectives

The City has identified the protection of the public, natural resources, water quality, and the preservation of existing City infrastructure as primary goals for their Master Plan. The stormwater quality retrofit objectives described below will support these goals.

Urban stormwater runoff is known to carry a variety of pollutants, including metals, oils, chemicals, bacteria, and nutrients. An emerging group of dissolved contaminants of concern are per- and-polyfluoroalky substances (PFAS). The City of Bend utilizes Magnesium Chloride (MgCl) for deicing operations during the winter months. The Deschutes River from Spring River to North Unit Diversion Dam (AU_ID = OR_SR_1707030104_05_102628) is listed as Category 5 Impaired for sedimentation, temperature (year round), turbidity, and pH, and is listed as Category 4 Impaired for flow modification and habitat modification. Sedimentation, turbidity and pH can all be influenced by urban stormwater.

The City staff has documented numerous instances of inlet clogging and movement of particulate material around and through the stormwater system in undesirable/unintended ways. These challenges can be referred as pretreatment challenges. Lack of pretreatment contributes to stormwater pollution in a couple of ways. First, when inlets are clogged with sediments, inlet capacity is reduced, leading to runoff flowing for longer distances over impervious surfaces and picking up more pollutants. Second, some sediments are conveyed through the piped system and discharged to the river along with pollutants that may adsorb to the particles. Typical pretreatment systems provide capture/removal of particulate matter and floatable materials.

The City staff has also documented both poor condition and maintenance access issues through camera inspection and maintenance records. Where condition or access issues have been documented, the need for retrofit is coupled with a need for repair or redesign of the pipe system.

The stormwater quality retrofit objectives are:

1. Reduce polluted discharges from largest contributing areas that do not already have treatment.

2. Prioritize removal of typical urban stormwater pollutants from higher intensity land uses.

3. Prioritize protecting the capacity and function of existing stormwater conveyance, treatment and infiltration facilities.

4. Prioritize retrofits for outfalls where repairs, rehabilitation, or realignment of pipes and structures is necessary to correct poor condition and/or lack of access to public infrastructure.

Needs Analysis

Otak has developed a framework for prioritizing outfall basins for retrofit in collaboration with the City of Bend by calculating a score identifying need for retrofit for each outfall basin. The score is calculated based on the following criteria: untreated area, pollutant load, sediment load, and maintenance access/pipe condition. Scoring for each criterion is explored below.

Untreated Areas

Reducing polluted discharges from the largest contributing areas that do not already have treatment has been identified as a water quality objective. There are 32 outfall drainage basins as shown in Figure 1. Three basins have multiple outfalls and are identified as such. One basin (labeled “TBD”) is delineated in the City’s stormwater inventory but has no associated point outfall identified with it in the inventory. The

City identified one very large basin draining to the Newport outfalls. Based on conversations with the City about the recent improvements along Newport Avenue, this large basin has been divided into two smaller basin polygons for the purposes of this assessment. The basins range in size from 0.2 acres to 497.4 acres. For the purposes of this assessment, areas within the MS4 basins draining to runoff treatment facilities or UICs are considered treated areas that are not in need of retrofit. Approximate treated areas are represented visually on Figure 1 and have been tabulated in Table 7.

Treated areas have been estimated at a planning level as follows:

- UICs: approximately 150 UICs have been identified within the boundaries of the outfall drainage basins. Each UIC is assumed to have 12,500 square feet of area draining to it based on a GIS analysis conducted by the City (City of Bend, 2024). Private stormwater swales: private stormwater swales are assumed to provide runoff treatment for the tax lots on which they are located.

- Public stormwater swales: public stormwater swales are assumed to have been sized using a 6% sizing factor, i.e., the swale area is 6% of the area that drains to it. While this rationale is not included in the COSM, it is a simplified approach used in low-infiltration (2 in/hr or less) areas in parts of north-western Oregon. Clean Water Services utilizes a 6% sizing factor (CWS, 2019).

- Contech StormFilter© cartridge vaults and catch basins: we collected drainage basin size for each StormFilter© vault by reviewing the drainage report.

After calculating treated area within a basin, the remaining basin area is considered untreated.

Untreated Area Scores

Outfall basins are scored from 0 to 3 according to the acreage of untreated area as shown in Table 1.

Table 1 Untreated Areas Scoring

Untreated Area (ac)	Score	Basins in this Category (each)
0-10	0	17
10-50	1	8
50-150	2	4
150+	3	2

Pollutant Load

Removal of typical urban stormwater pollutants has been identified as a water quality objective. Pollutant loads can be correlated to land uses and high-traffic roadways. A desktop GIS review of roadway classifications revealed that only moderate variation of roadway types is present within the outfalls study area, with the highest polluting roadways in the City (highways, etc.) being located outside of the area. However, roadways are spatially correlated with land uses such that higher-traffic count roads are adjacent to more intense land uses. Therefore, for this assessment both land use and roadway pollutant intensity are represented by the City's established zoning. Otak classified zoning into three intensities of pollutant generation, as follows:

- Low pollutant generating land uses include residential, urban reserve, professional offices, and most public facilities such as parks and schools (those with less than 80% impervious area). Zoning codes included in this category are RL, RS, RM, RM-10, RH, UAR, PO, and PF.

- Moderate pollutant generating land uses include mixed uses and commercial uses, as well as public facilities with more than 80% impervious area. A visual inspection of the public facilities within the outfall drainage basins shows two bridge areas as being more than 80% impervious. Zoning codes included in this category are ME, MR, MN, MU, CB, CC, CL, CG, and CN.
- High pollutant generating land uses include industrial and special planned districts. Zoning codes included in this category are IG, IL, and SM.

Pollutant Load Scores

Outfalls are scored from 0 to 3 for pollutant load based on the relative amounts of area in each land use category. Table 2 summarizes the scoring for this factor. The scoring is additive; an outfall basin is awarded a point for each criterion it meets.

Table 2 Pollutant Load Scoring

Description	Add Score	Basins Eligible for this Point (each)
Only "Low" Loading	0	20
Any amount of "High" Loading	Add 1	1
At least 1 acre of "Moderate" Loading	Add 1	10
More than 10 acres of "Moderate" Loading	Add 1	4
Maximum Score is 3		

The counts of basins by total score are listed below:

- Score 0: 20 basins
- Score 1: 7 basins
- Score 2: 4 basins
- Score 3: 0 basins

Sediment Load

Protecting the capacity and function of existing stormwater treatment and infiltration facilities has been identified as a water quality objective. Under existing conditions, the City has collected evidence through tracking drainage complaints and maintenance service calls that sediment in the collection and conveyance system from erosion and winter street maintenance threatens the capacity, function, and longevity of collection, conveyance, and runoff treatment systems within the outfalls basins.

Within the MS4 area, Awbrey Butte has slopes greater than 15%, which then flatten out as it approaches the river (slopes less than 5% slope). Although portions of Awbrey Butte have been developed under more recent and more protective stormwater standards, sediment is still deposited and transported to storm systems on the roads due to runoff flowing over bare or erodible soils and landscaping and sanding for winter traction (HDR, 2017). City staff reported that some of the main roads that lead up or down from Awbrey Butte transport significant sediment.

The City of Bend has soils that are predominantly friable and non-cohesive (GSI, 2020). Older parts of the City are lacking curb and gutter infrastructure. In some cases, low exposure curbs approximately three inches tall are present. In these locations, loose sediment readily moves across roadways, alleys, sidewalks, driveways, paths, etc. during storms. The City applies sand during the winter to provide traction during icy conditions. The steepest roads in the City receive the most sand.

The City's staff reported that most of their catch basins have sumps, but the depth of these sumps may vary. The City has also identified that some of the filter media cartridge treatment vaults lack pretreatment structures that would extend the service life of the cartridges by capturing trash and larger sediment particles prior to runoff entering the filter vault. Implementation of pretreatment vaults would lessen frequency of clogging of filters and bypassing of flows during storm events.

For the purposes of this assessment, site topography has been identified as an indicator of higher sediment loads.

Slopes have been separated into three categories: "Flat," "Moderate," and "Steep." Flat slopes are defined as less than 5% slopes, Moderate slopes are greater than or equal to 5% and less than or equal to 15% slopes, and Steep slopes are defined as greater than 15% slopes.

Sediment Load Scores

We calculated a "slope factor" in Excel for each outfall basin derived from the inverse of the relative proportions of each slope category normalized against basin size. Then we calculated a score for slope from the slope factor, where higher slope factors are associated with higher scores. Larger slope factors correspond to higher scores (Table 3).

Table 3 Sediment Load Scoring

Slope Factor	Score	Basins in this Category
0.00-0.25	0	7
0.25-0.40	1	15
0.40-0.55	2	4
0.55-1.00	3	5

Related Known Issues

The preliminary planning steps for the Stormwater Master Plan have identified numerous known issues within the outfall basins. Additional emphasis is given in this assessment where there are documented pipes or structures in poor condition based on closed-circuit television (CCTV) investigation, documented maintenance access issues, drainage issues, or documented sedimentation issues. See related known issues descriptions in the notes on Table 7.

Related Known Issues Scoring

The City has provided a list of drainage known issues with priority scores attached to them. A score of 3 (the highest score) is given to outfall identified by the City's maintenance team as being "Priority 1" or highest priority known issue. Of the remaining known issues within the MS4 permit area, the only "Priority 2" known issue was in the same basin as a "Priority 1" known issue and the only "Priority 3" known issue was listed as being already resolved as of July 2024. After review of each of the specific known issues in each basin, a score of 0, 1, or 2 was applied based on engineering judgement of severity of the known issues. A total of 8 outfall basins have related active known issues.

Scoring Input

The scoring input values were geo-processed and mapped for visualization (Figure 2, Figures attached).

Results

The outfalls are scored from 0 to 9 by adding scores for each of the four factors above. Increasing score corresponds to increasing need for retrofit.

The average score of the outfall basins using the above scoring criteria is a score of 3. The top seven highest scoring basins have scores of 4-9. At the low end of scoring, three basins received scores of 0. Figure 1 below provides a histogram of the outfall scoring.

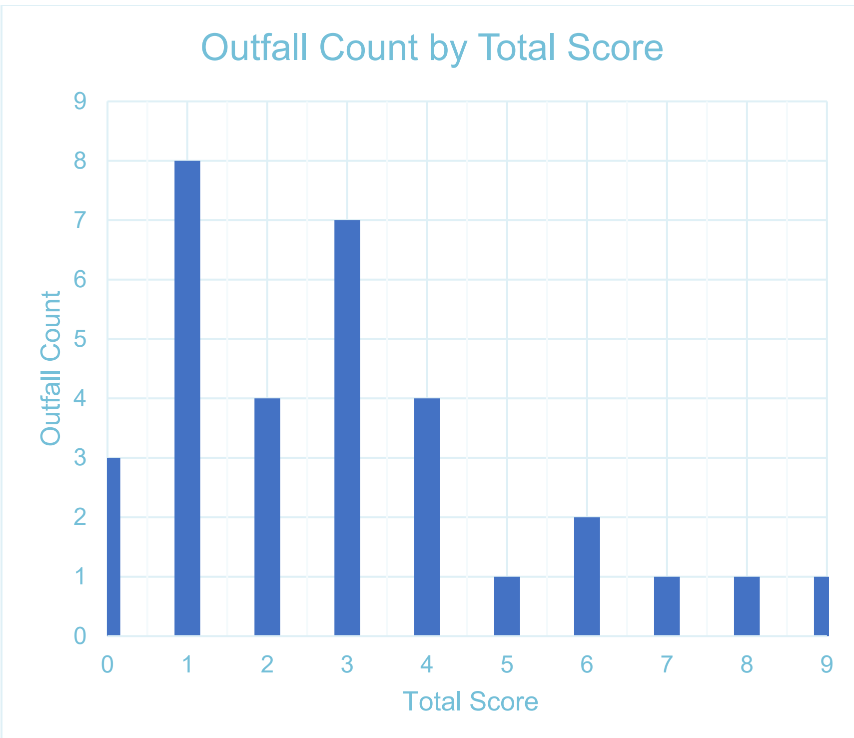


Figure 1 Outfall Retrofit Needs Score Distribution Chart

We ranked basins based on score. See Table 4 below for the outfalls in alphanumeric order, with high score / low rank denoting greatest need. There are many “tie” scores between outfalls. See Conclusions for recommendations to proceed.

Table 4 Outfall Basins' Scores and Ranks

Outfall ID	Untreated Score	Slope Score	Zoning Score	Known Issue Score	Total Score	Rank
DOF000012	0	1	0	0	1	22
DOF000013	3	3	0	0	6	4
DOF000016	0	0	0	0	0	30
DOF000017	1	0	0	0	1	22
DOF000018	1	0	2	3	6	4
DOF000019	1	1	0	2	4	7
DOF000020	2	1	2	2	7	3
DOF000022	1	1	0	1	3	11
DOF000024	2	3	1	2	8	2
DOF000034	0	1	0	0	1	22
DOF000039	2	2	0	0	4	7
DOF000040	0	1	0	0	1	22
DOF000065	0	0	1	0	1	22
DOF000066	0	1	1	0	2	18
DOF000070	0	0	0	0	0	30
DOF000108	0	1	0	0	1	22
DOF000109	0	0	0	0	0	30
DOF000110	0	1	0	0	1	22
DOF000125	0	2	1	0	3	11
DOF000127	1	1	2	0	4	7
DOF000128	1	1	0	3	5	6
DOF000130	1	1	0	0	2	18
DOF000131	2	1	1	0	4	7
DOF000192	0	2	0	0	2	18
DOF000193	0	1	0	2	3	11
DOF000200 & DOF000222 & DOF000223	0	0	1	0	1	22
DOF000207	0	3	0	0	3	11
DOF000220	0	3	0	0	3	11
DOF000221	0	2	1	0	3	11
DOF000266 & DOF000014S	2	1	0	0	3	11
DOF000266 & DOF000014N	3	3	0	3	9	1
TBD	1	1	0	0	2	18

Conclusions

Otak recommends that the highest six ranked basins be considered in the next stage of the master plan. The highest-ranking basin is very large (nearly 500 acres) and has numerous opportunities for potential retrofits. The basins recommended for further consideration are listed as ranked in Table 5.

Table 5 Priority Outfalls for Further Consideration

Outfall ID	Total Score	Rank
DOF000266 & DOF000014N	9	1
DOF000024	8	2
DOF000020	7	3
DOF000013	6	4
DOF000018	6	4
DOF000128	5	6

There is a four-way tie for the seventh-ranked outfalls, which the City could consider in an additional phase of outfall retrofits, as listed in Table 6.

Table 6 Secondary Outfalls for Further Consideration

Outfall ID	Total Score	Rank
DOF000019	4	7
DOF000039	4	7
DOF000127	4	7
DOF000131	4	7

Figure 3 (Figures attached) shows that the outfall basins ranking highest in need are mostly located west of the Deschutes river and tend to be larger basins. Large basins offer opportunities for larger "regional" facilities that simplify maintenance by centralizing captured pollutants. The "DFO000266 & DOF000014" basin has been split into north (N) and south (S) subbasins for this purpose. Even though these two subbasins outfall to the same location, there have been significant improvements to the south subbasin along Newport Avenue. There remain many opportunities in the South Awbrey Butte area to the north. The rating and ranking classified the large north basin as the highest priority basin. A challenge with regional facilities is often the space that they require (whether vegetated or underground), which can be prohibitively expensive where valuable real estate / easements must be purchased. Regional vegetated/above-ground facilities may be difficult to locate due to the land uses in the most highly ranked basins. However, stormwater pretreatment systems such as hydrodynamic separators may centralize pollutants for easier maintenance if they can be located within the existing right-of-way.

Table 7 **Outfall Rating and Ranking**

		Untreated Area			Slopes								Zoning							Related Known Issues		Total Score and Rank	
Outfall ID	Basin Area	Untreated Area (acres)	Untreated Percentage	Untreated Score	Steep (acres)	Steep (percentage)	Moderate (acres)	Moderate (percentage)	Flat (acres)	Flat (percentage)	Slope Factor	Slope Score	High Load (acres)	High Load (percentage)	Medium Load (acres)	Medium Load (percentage)	Low Load (acres)	Low Load (percentage)	Zoning Score (See Notes Table)	Known Issues (See Notes Table)	Issues Score	Total Score	Rank
DOF000012	3.7	3.7	100%	0	0.1	4%	0.7	18%	2.9	78%	0.36	1	0	0%	0.0	0%	3.7	100%	0		0	1	**22**
DOF000013	170.4	160.3	94%	3	16.9	10%	75.4	44%	78.1	46%	0.58	3	0	0%	0.0	0%	170.5	100%	0		0	6	**4**
DOF000016	7.9	7.9	100%	0	0.0	0%	0.7	8%	7.2	91%	0.16	0	0	0%	0.0	0%	7.9	100%	0		0	0	**30**
DOF000017	11.2	11.0	98%	1	0.0	0%	1.3	11%	9.9	88%	0.20	0	0	0%	0.0	0%	11.2	100%	0		0	1	**22**
DOF000018	24.2	20.5	85%	1	0.2	1%	2.4	10%	21.5	89%	0.20	0	0	0%	19.0	79%	5.2	21%	2	Yes	3	6	**4**
DOF000019	11.3	11.1	98%	1	0.1	1%	1.8	16%	9.3	83%	0.29	1	0	0%	0.0	0%	11.3	100%	0	Yes	2	4	**7**
DOF000020	56.0	52.7	94%	2	0.6	1%	9.6	17%	45.8	82%	0.30	1	0	0%	11.0	20%	45.0	80%	2	Yes	2	7	**3**
DOF000022	21.4	21.0	98%	1	0.3	2%	4.2	20%	16.8	79%	0.34	1	0	0%	0.0	0%	21.3	100%	0	Yes	1	3	**11**
DOF000024	70.4	65.9	94%	2	10.7	15%	21.7	31%	37.9	54%	0.59	3	0	0%	4.6	6%	65.9	94%	1	Yes	2	8	**2**
DOF000034	0.7	0.6	75%	0	0.0	0%	0.2	22%	0.6	77%	0.36	1	0	0%	0.0	0%	0.7	100%	0		0	1	**22**
DOF000039	97.1	91.7	94%	2	10.2	11%	18.0	19%	68.9	71%	0.45	2	0	0%	0.7	1%	96.4	99%	0		0	4	**7**
DOF000040	14.4	9.4	65%	0	0.3	2%	2.9	20%	11.2	78%	0.35	1	0	0%	0.0	0%	14.4	100%	0		0	1	**22**
DOF000065	9.2	8.9	97%	0	0.2	2%	1.0	11%	8.0	87%	0.24	0	0	0%	1.0	11%	8.2	89%	1		0	1	**22**
DOF000066	1.3	1.1	89%	0	0.1	5%	0.2	17%	1.0	77%	0.37	1	0	0%	1.3	100%	0.0	0%	1		0	2	**18**
DOF000070	1.4	1.4	100%	0	0.0	0%	0.1	6%	1.3	94%	0.12	0	0	0%	0.0	0%	1.4	100%	0		0	0	**30**
DOF000108	0.3	0.3	100%	0	0.0	11%	0.0	4%	0.3	82%	0.31	1	0	0%	0.1	43%	0.2	57%	0		0	1	**22**
DOF000109	0.4	0.4	100%	0	0.0	0%	0.0	6%	0.3	93%	0.14	0	0	0%	0.4	100%	0.0	0%	0		0	0	**30**
DOF000110	4.2	4.2	100%	0	0.1	2%	0.7	17%	3.4	81%	0.31	1	0	0%	0.0	0%	4.2	100%	0		0	1	**22**
DOF000125	0.8	0.6	79%	0	0.1	8%	0.2	27%	0.5	64%	0.51	2	0.3	34%	0.0	6%	0.4	59%	1		0	3	**11**
DOF000127	52.7	32.6	62%	1	1.7	3%	6.6	13%	44.5	84%	0.27	1	0	0%	45.5	86%	7.2	14%	2		0	4	**7**
DOF000128	12.7	12.7	100%	1	0.1	1%	2.0	16%	10.6	83%	0.28	1	0	0%	0.0	0%	12.7	100%	0	Yes	3	5	**6**
DOF000130	20.0	19.5	98%	1	0.6	3%	3.8	19%	15.6	78%	0.35	1	0	0%	0.0	0%	20.0	100%	0		0	2	**18**
DOF000131	67.4	63.6	94%	2	0.3	0%	10.2	15%	56.9	84%	0.26	1	0	0%	2.6	4%	64.8	96%	1		0	4	**7**
DOF000192	7.8	6.8	87%	0	0.9	11%	1.6	21%	5.3	68%	0.48	2	0	0%	0.0	0%	7.8	100%	0		0	2	**18**
DOF000193	7.8	7.5	96%	0	0.5	6%	1.3	16%	6.1	77%	0.37	1	0	0%	0.0	0%	7.8	100%	0	Yes	2	3	**11**
DOF000200 & DOF000222 & DOF000223	1.1	1.0	88%	0	0.0	0%	0.1	8%	1.0	91%	0.17	0	0	0%	1.0	89%	0.1	11%	1		0	1	**22**
DOF000207	0.2	0.2	100%	0	0.1	31%	0.0	29%	0.1	39%	0.67	3	0	0%	0.2	100%	0.0	0%	0		0	3	**11**
DOF000220	3.7	3.4	92%	0	0.3	7%	1.6	44%	1.8	48%	0.56	3	0	0%	0.0	0%	3.7	100%	0		0	3	**11**
DOF000221	1.6	1.3	85%	0	0.1	5%	0.4	24%	1.1	70%	0.45	2	0	0%	1.6	100%	0.0	0%	1		0	3	**11**
DOF000266 & DOF000014S	95.3	55.1	58%	2	2.1	2%	17.5	18%	75.8	79%	0.33	1	0	0%	16.1	17%	79.2	83%	0		0	3	**11**
DOF000266 & DOF000014N	497.4	486.5	98%	3	73.5	15%	278.6	56%	145.2	29%	0.58	3	0	0%	0.6	0%	496.9	100%	0	Yes	3	9	**1**
TBD	11.5	10.6	93%	1	0.3	3%	2.3	20%	8.9	77%	0.36	1	0	0%	0.0	0%	11.5	100%	0		0	2	**18**

Updated 8/27/2024

Related Known Issues Notes

Outfall ID	**Description**
DOF000018	Rationale: Score this as 3, City identified two "Priority 1" issues in the basin related to long pipe runs with limited access for maintenance.
DOF000019	Rationale: Score this as 2, City reported that this issue occurred at multiple places in the neighborhood, and this was concern for private property.
DOF000020	Rationale: Score this as 2, Tear in the pipe represents potential sinkhole concern.
DOF000022	Rationale: Score this as 1, CCTV shows root intrusion and a void but no outward indicators of an issue.
DOF000024	Rationale: Score this as 2, damage to pipe is a potential safety concern (though it is on private property), there are reported inlet clogging problems, and some flooding.
DOF000128	Rationale: Score as 3, there are multiple "Priority 1" issues identified by the City staff in this basin.
DOF000193	Rationale: Score as 2, gas line through a pipe with a "huge void" is a safety and utility concern.
DOF000266 & DOF000014 N	Rationale: Score as 3, Awbrey Butte is one of the highest priority stormwater issue locations in the City.

Zoning Notes

Outfall ID	**Description**
DOF000266 & DOF000014 S	Rationale: This basin ranks highly based on land use zone, however Newport Ave has had significant improvements to treat runoff, substantially attenuating the impact of the land use zoning. This basin has been scored "zero" for zoning.

References

GSI, 2020. *Stormwater Infiltration Evaluation Update*. October 2020. GSI Water Solutions, Inc.

HDR, 2017 *South Awbrey Butte Drainage Study Final Improvement Plan.* October 17, 2017. HDR Engineering, Inc.

Central Oregon Intergovernmental Council, 2010. *Central Oregon Stormwater Manual.* Update August 2010.

CWS, 2019. *Design and Construction Standards, Chapter 4.* Clean Water Services. November 12, 2019.

City of Bend, 2024. *Groundwater Protectiveness Demonstration Update for Per- and Polyfluoralkyl Substances (PFAS), City of Bend, Oregon.* April 14, 2024.

Figures

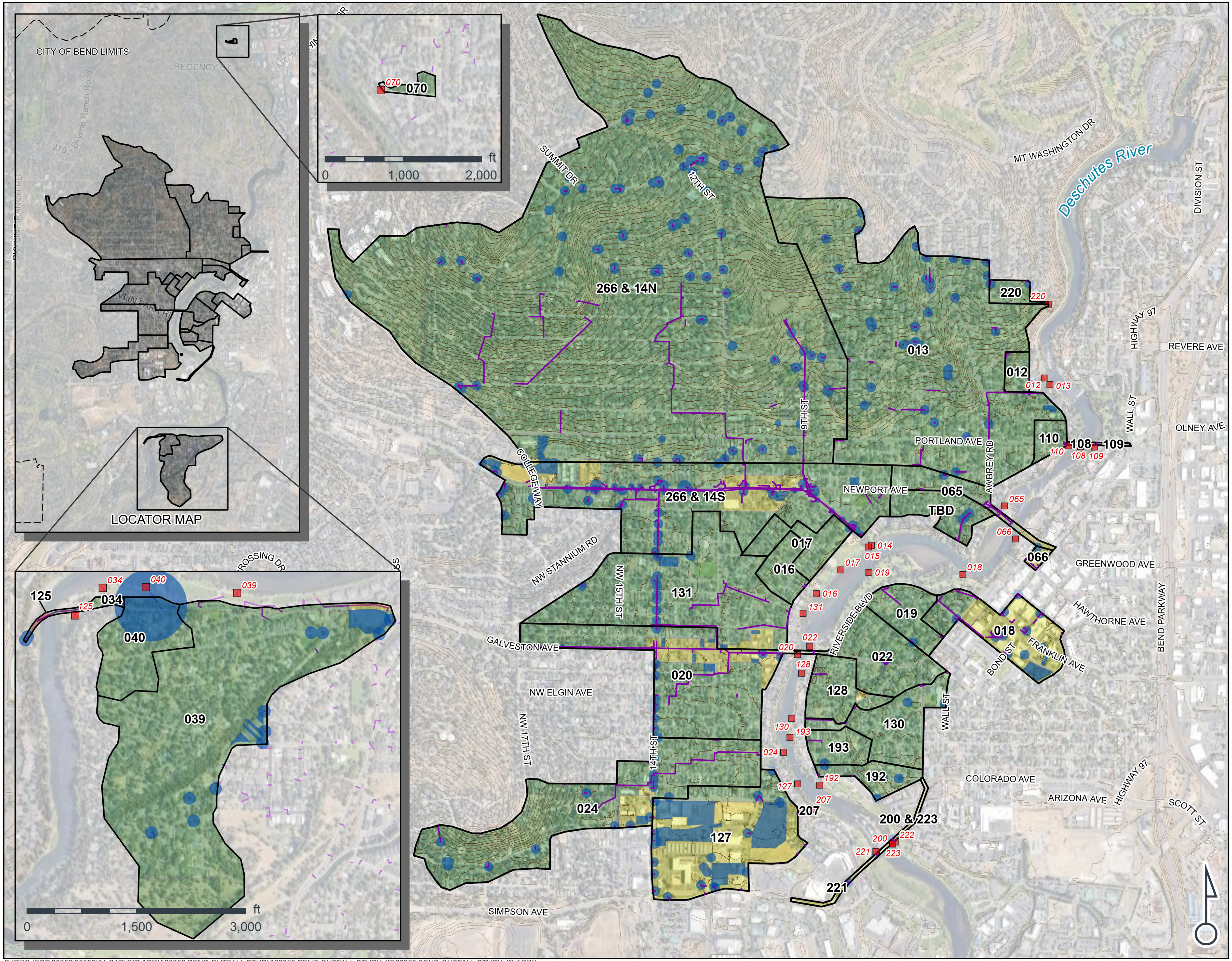


FIGURE 2

STORMWATER OUTFALL NEEDS ASSESSMENT INPUTS

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

- Outfalls
- Storm Main
- Outfall Basin Delineation
- Representative Treated Areas
- Contours (10')

Zoning Type Pollutant Load

- High
- Moderate
- Low

0 1,500 3,000 ft

Data Sources: City of Bend, USGS, Google Maps.
Date: 8/20/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

Otak

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND OUTFALL STUDY\20359 BEND OUTFALL STUDY JR\20359 BEND OUTFALL STUDY JR.APRX

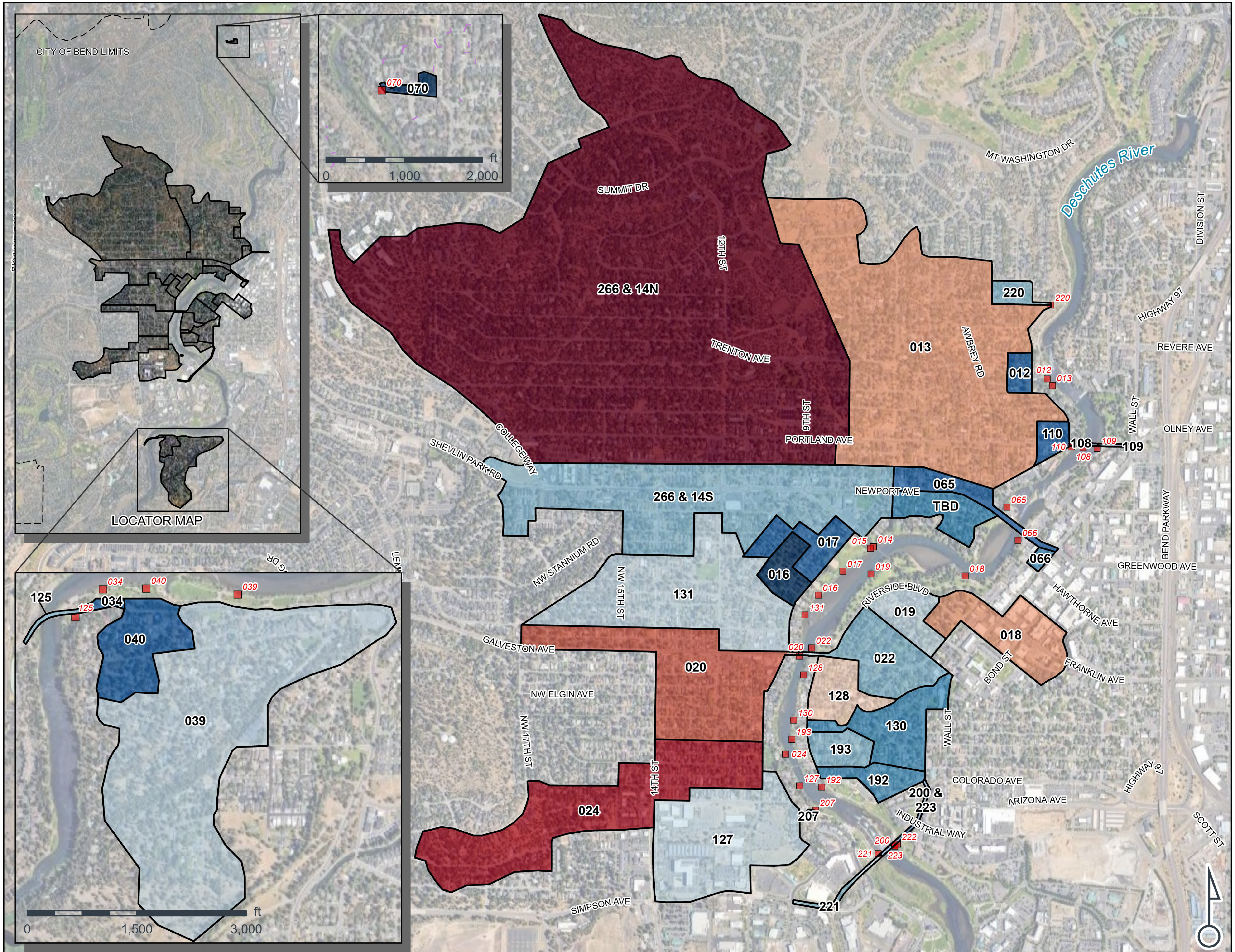


FIGURE 3

STORMWATER OUTFALL BASIN RANKING

BEND STORMWATER MASTER PLAN

BEND, OREGON

LEGEND

- Outfall Basin Delineation
- Outfalls

Outfall Basin Ranking

Rank

- 1
- 2
- 3
- 4
- 6
- 7
- 11
- 18
- 22
- 30

0 1,500 3,000 ft

Data Sources: City of Bend, USGS, Google Maps.
Date: 8/27/2024
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

Otak

O:\PROJECT\20300\20359\04 CAD\GIS\APRX\20359 BEND OUTFALL STUDY\20359 BEND OUTFALL STUDY JR\20359 BEND OUTFALL STUDY JR.APRX

FINAL TECHNICAL MEMORANDUM

Modified Drywell Siting Criteria and Drillhole Decommissioning Framework, City of Bend, Oregon

To:	Trista Kobluskie, PE / Otak, Inc.
From:	Matt Kohlbecker, RG / GSI Water Solutions, Inc. Casey McGuire / GSI Water Solutions, Inc.
CC:	Elisabeth O'Keefe / City of Bend Lori Faha, PE / City of Bend
Date:	July 12, 2024

1. Introduction

This technical memorandum (TM), prepared by GSI Water Solutions, Inc. (GSI) for Otak, Inc. (Otak), presents an evaluation of modified drywell suitability and a drillhole replacement prioritization to inform the City of Bend's (City) updated Stormwater Master Plan. The following sections provide an overview of Underground Injection Control (UIC) configurations, the purpose and objectives of this TM (Section 1.2), and the organization of this TM (Section 1.3).

1.1 Underground Injection Control Types and Configuration

The City uses about 6,500 UICs to manage stormwater runoff from public rights-of-way (GSI, 2023). According to the Oregon Administrative Rules, a UIC is a well, improved sinkhole, or other subsurface fluid distribution system that is used for the subsurface emplacement or discharge of fluids[1]. About 5,500 of the City's UICs are drywells, and about 1,000 of the City's UICs are drillholes. Drywells are typically 10 to 20 feet deep cylindrical structures constructed of 4-foot diameter concrete rings with weep holes. Drillholes are typically 6-inch diameter open boreholes completed with a steel surface casing (generally 10 to 20 feet) (GSI, 2023) that may be up to 100 feet deep (the maximum UIC depth allowable by state law for rule authorized UICs[2]). Recently, new construction techniques have been introduced in Oregon that allow for installation of drywells to up to 100 feet deep (modified drywells).

Drillholes are more common west of the Deschutes River where low-permeability volcanic ash layers are prevalent, and in older parts of the City. New drillholes have not been permitted in the City standards for several years due to maintenance issues, the lack of pretreatment, and due to the difficulty and expense of retrofitting.

[1] OAR 340-044-0005(24)
[2] OAR 340-044-0018(3)(a)(G)

1.2 Purpose and Objectives

The purpose of this TM is to provide the City with information about new-to-Oregon stormwater infiltration devices (i.e., modified drywells) and a prioritization framework for decommissioning of old stormwater infiltration devices (i.e., drillholes) to inform the City's 2024 Stormwater Master Plan update. The objectives of the TM are:

- Provide an overview of modified drywells, including advantages and disadvantages.
- Develop criteria for minimizing the risk of environmental contamination from modified drywells.
- Develop a prioritization framework for decommissioning drillholes.

1.3 Technical Memorandum Organization

The remainder of this TM is organized as follows:

- Section 2: Provides criteria for siting modified drywells
- Section 3: Outlines drillhole replacement and upgrade prioritization

2. Modified Drywell Siting Criteria

Conventional drywells, which comprise the City's approximately 5,500 drywells, are 4-foot diameter structures typically excavated with a hydraulic clam shell that have a maximum depth of approximately 40 feet in Oregon. Modified drywells have a similar diameter as conventional drywells but are excavated with large-diameter augers. Modified drywells are deeper than conventional drywells, generally up to 100 feet deep depending on local geology. Two examples of as-built modified drywells are shown in Figure 1.

Modified drywells have been used in the desert southwest since the 1970s; they have been installed at significant depths to bypass shallow, low-permeability caliche layers and rock. Recently, the City of Gresham, Oregon, constructed a modified drywell to bypass a shallow perched aquifer, and King County has managed stormwater runoff in dense residential neighborhoods by drilling 50 to 100 feet deep drywells to bypass shallow, low permeability glacial till and infiltrate stormwater into the underlying sands (Radford, 2016). The City of Bend has been receiving increased requests from developers to construct modified drywells.

This section summarizes the advantages of modified drywells (Section 2.1), the disadvantages of modified drywells (Section 2.2), criteria for siting modified drywells to minimize the risk of environmental contamination (Section 2.3), and conclusions (Section 2.4).

2.1 Advantages of Modified Drywells

Advantages of modified drywells (when compared to drillholes or traditional drywells) include the following:

- **Footprint.** Modified drywells have a small footprint because the pretreatment device is installed within the same borehole as the drywell, making modified drywells a good option in urban areas where space is limited.
- **Bypass shallow, low-permeability soil layers**. Modified drywells can bypass shallow soils characterized by low infiltration rates (e.g., silt, clay, or volcanic ash), targeting deeper soils and sediments have higher infiltration rates.
- **Larger storage volume and improved treatment compared to a drillholes.** Because of their large-diameter, modified drywells can store a larger volume of water than a drillhole, thereby allowing the water to slowly exfiltrate from the drywell in low-permeability soil environments. In addition, unlike drillholes, proprietary modified drywells are equipped with pretreatment devices like a sedimentation

manhole to allow for settling of stormwater solids, hydrocarbon-absorbent pillows, and intake screens/debris shields.

- **More head during infiltration.** Higher infiltration rates can be achieved at modified drywells because the drywell can accommodate additional mounding (i.e., head) during infiltration.

2.2 Disadvantages of Modified Drywells

Disadvantages of modified drywells (when compared to drillholes or traditional drywells) include the following:

- **Higher risk of causing groundwater contamination.** The highest risk to groundwater is from contaminants in stormwater that are toxic, common, mobile, and persistent (GSI, 2013). Pollutant fate and transport modeling by GSI (2011) showed that most common stormwater pollutants do not reach groundwater as long as there are five feet of vertical separation between the bottom of the drywell and groundwater. However, recent modeling by GSI (2024) showed that significantly larger vertical separation distances are needed to protect groundwater from emerging pollutants [i.e., per- and polyfluoroalky substances (PFAS) and simazine will reach groundwater unless there are about 53 feet and 37 feet of vertical separation, respectively]. Because modified drywells are deeper than conventional UICs, they minimize vertical separation distance and, therefore, increase the risk of groundwater pollution.
- **Difficult and expensive to clean in the case of a spill of hazardous material.** Traditionally, drywells are cleaned via pressure washing, scraping of the interior walls, and/or vacuuming with a vactor truck if a spill occurs. However, because vactor trucks are not effective on drywells that are more than 40 feet deep, removal of a spill of hazardous materials from a modified drywell cannot not be performed using traditional techniques. Options are drill or pump rigs and bailers to remove spilled material from deep drywells, which would significantly increase the cost of cleanup. In addition, remediation of spilled material that has infiltrated into soils surrounding the drywell would be significantly more expensive due to the increased depth.
- **Novelty and lack of performance data.** There is limited research on modified drywell performance in Oregon over time due to the relative newness in the Pacific Northwest. Geosyntec (2020) noted data gaps including Infiltration testing guidance prior to UIC citing and drywell lifecycle research, both of which would be beneficial when planning a new UIC. However, it should be noted the City of Gresham's modified drywell has experienced no performance declines since it was constructed in the Spring of 2022.
- **Often more expensive than traditional UICs.**

2.3 Criteria to Minimize Risk of Environmental Contamination from Modified Drywells

This section provides criteria to minimize the risk of environmental contamination from modified drywells, including siting criteria (Section 2.2.1), construction practices (Section 2.2.2), spill mitigation (Section 2.2.3), pretreatment (Section 2.2.4), and operations and maintenance (Section 2.2.5).

2.3.1 Siting Criteria

Proper drywell siting minimizes the risk that a drywell will contaminate groundwater, and is especially important for modified drywells because groundwater contamination is significantly more expensive to clean up. As long as a 53-foot vertical separation distance between the base of the UIC and the seasonal high of groundwater are adhered to (based on the findings of GSI's 2024 Groundwater Protectiveness Demonstration Update), groundwater contamination from common stormwater pollutants should not be of concern. Contamination caused by spills of hazardous material poses the highest risk of groundwater contamination.

Drywell siting criteria are covered in Bend's standards (2023). Drywell siting should consider the local factors such as land use (which will affect the quality of the water discharging to the drywell), traffic volume, water well locations, groundwater depth, and geology. See Section 3 prioritization criteria for further information on these topics. There is a low risk that drywells meeting all of the following criteria will be impacted by a spill. Therefore, modified drywells may be sited in drainage basins that meet these criteria (see green-light areas in Figure 2):

- Residential land use
- Streets that experience less than 1,000 vehicle trips per day,
- Outside of two-year time-of-travel zones from municipal supply wells and >500 feet from water wells, and
- Outside of areas with perched groundwater (i.e., the Old Mill District Perched Area and North Bend Perched Area).

Developers may request that modified drywells be used in areas that do not meet all these criteria. The City may consider approving modified drywell use in yellow-light areas identified in Figure 2, such areas as long as additional protective measures are incorporated into the drywell design (e.g., spill control manholes, as shown in Figure 1). In no case should modified drywells be constructed within 500 feet of a water well or within the two-year time-of-travel zone of a municipal supply well.

The City of Gresham does not have formal siting criteria; however, the one modified drywell that has been installed so far was installed to meet the following protectiveness:

- Residential streets (< 1,000 trips per day),
- Outside of two-year time-of-travel zones from municipal supply wells, and
- Must have a shut off valve.

2.3.2 Construction

The following construction methods mitigate groundwater contamination, and should be common practice at a site where a modified drywell is being constructed:

- Drywell inlets should be sealed with two layers of UV protected geotextile material until nearby construction is complete, to prevent sediment ingress (ADEQ, 2018).
- Drywells should be covered by a solid manhole so that flow into the drywell is solely through the interceptor inlet, and the manhole should be bolted and labelled 'stormwater only' to prevent tampering (ADEQ, 2018).
- Manholes installed at modified drywells should be modeled on the "spill control manhole" examples provided in Figure 1 to provide some level of additional spill protection.

2.3.3 Spill Mitigation

To mitigate the effect of spills, GSI recommends that Bend (similarly to what GSI previously recommended to the City of Gresham) have a spill response plan in place and automatic shut-off-valves that close when spills are detected. In addition, if the modified drywell is constructed of an infiltration pipe that runs inside the annular space between the sedimentation manhole and borehole wall, and then curves underneath the bottom of the sedimentation manhole, GSI recommends a cleanout be installed so that the infiltration pipe below the sedimentation manhole can be accessed by a bailer to clean material out of the drywell, or a brush to clean the drywell.

2.3.4 Pretreatment

Pretreatment options for stormwater discharges are described in DEQ's Industrial Stormwater Best Management Practices Manual (Jurries and Ratliff, 2013).

Pretreatment recommendations for drywell type are described in Table , and should be considered for modified drywells. The best pretreatment option for a site will be determined by site characteristics and known potential pollutants at a site.

Table 1. Pretreatment Recommendations for Drywell Type.

Drywell Type	Pretreatment Goals	Types of BMPs Recommended	Additional Spill Control and Outreach Recommendations
Conventional	Manage rate of clogging[1], oil control, metals treatment	From Central Oregon Stormwater Manual (2010): ▪ Low impact development ▪ Infiltration swale ▪ Vegetated filter strips ▪ Oil/water separator ▪ Wetponds ▪ Extended detention dry ponds ▪ Evaporation ponds ▪ Grassy swales ▪ Sedimentation manholes ▪ Emerging technologies ▪ Treatment trains	N/A
Modified	"Conventional" goals, plus: ▪ Isolate and contain spills, and ▪ Capture trash ▪ Provide treatment of particulate-bound pollutants	From Geosyntec (2020): ▪ Oil absorbent pillows ▪ Debris screen ▪ Hydrodynamic separator ▪ TAPE Pretreatment GULD[2] Bioretention ▪ Media filter ▪ TAPE Basic GULD[3] (with sump element) ▪ Alternative pretreatment BMP selected based on clogging and water quality considerations (Subject to LEA approval)	From Geosyntec (2020): ▪ Conduct source control investigation and outreach for potential sources of human waste ▪ Closed bottom sump with elevated outlet, documentation of a spill response plan and adequately trained spill response team, or demonstration of low risk of spills in the drainage area ▪ Include an automatic shutoff valve

Notes

[1]Clogging is not a groundwater quality risk, however it affects the necessary maintenance intervals and lifecycle cost of a drywell and needs to be considered in selection of pretreatment BMPs.

[2]TAPE Pretreatment General Use Level Designation (GULD) BMPs are BMPs that meet 50% removal of TSS, when influent is between 100 and 200 mg/L.

[3]TAPE Basic GULD BMPs are BMPs that meet 80% removal of TSS when influent is between 100 and 200 mg/L.

2.3.5 Operations and Maintenance

Inspection and maintenance recommendations for modified drywells are outlined below. Records should be kept of all inspections, problems, and actions taken.

Inspections

Inspections should be conducted according to a schedule, ideally at least annually. The inspection should include but not be limited to the following (ADEQ, 2018):

- Ensure that no hazardous materials are being used or stored in the area.
- Check for staining, discoloration, or residue on the surrounding the area (i.e. oil stains on pavement), or odors, all of which could indicate potentially contaminating materials.
- Check settling chambers and interceptor compartments for debris and sediment (which should be removed under maintenance).
- Check chemical absorbents (where present) and replace if discolored and/or below the water surface.
- Track performance, ranging from documenting failure (e.g., performance) to testing modified drywells and comparing performance over time.

Maintenance

Maintenance of drywells should include cleaning filters and screens, replacement of chemical absorbents, and removal of sediment, debris, and trash:

- ADEQ (2018) recommends that debris and silt be removed at regularly scheduled times, i.e. at least annually, or at a minimum at the following times:
    - "In paved areas when the sediment level fills 10 percent of the effective settling capacity.
    - In landscaped areas when the sediment level fills 25 percent of the effective settling capacity.
    - When ownership of the property changes.
    - When material not resulting from storm water or urban surface runoff enters the drainage system interceptor or drywell settling chamber."

Regular street cleaning should also be conducted to reduce debris sources that could be mobilized by runoff to enter the UICs.

2.4 Advantages, Disadvantages, and Risk Minimization Conclusions

Table below summarizes the modified drywell disadvantages (i.e., higher risk of causing groundwater contamination, difficult to clean, and lack of performance data) and options for minimizing the risk associated with each disadvantage.

Table 2. Modified Drywell Disadvantages and Mitigation Options.

Disadvantage	Risk Minimization Option	Option Details
Groundwater contamination	Siting	Establish siting criteria based on land use, perched groundwater areas, setbacks from water wells, and vehicle trips per day
	Construction	Seal drywell inlets, secure manhole cover, sump
	Spill mitigation	Spill response plan, shut off valve
	Pretreatment	Require enhanced pretreatment (e.g., spill control manholes)

Disadvantage	Risk Minimization Option		Option Details
	Operations and Maintenance		Inspections at least annually, regular cleaning of drywell and street
Difficult/expensive to clean	Preventative measures (so cleaning not required)	Siting	Setbacks from potential sources of large sediment load associated with construction sites, or implement other best management practices
		Construction	Seal drywell inlets, secure manhole cover, sump
		Spill mitigation	Spill response plan, automatic shut off valve, install cleanout to access infiltration pipe
		Pretreatment	Require enhanced pretreatment (e.g., engineered media filters, vegetated strips, manufactured devices, and detention basins)
	Operations and Maintenance		Inspections at least annually, regular cleaning of drywell and street
Novelty and lack of performance data	Operations and Maintenance		Track and compile records of drywell failure and performance testing

3. Prioritization Framework for Drillhole Decommissioning

A drillhole is a 6" diameter open hole, typically completed with 20 feet of surface casing, that varies in depth from 10 feet to over 100 feet deep (City of Bend, 2012). Drillholes have not been allowed in the City's Standards and Specifications for several years, in part because they require frequent maintenance, are characterized by a lack of pretreatment, and they can be difficult and expensive to retrofit. This section provides a framework for prioritizing drillhole retrofits and/or replacements to meet the City's goal of efficiently managing stormwater by infiltration in a manner that is protective of groundwater quality.

3.1 Methods for Developing Framework to Prioritize Drillhole Decommissioning

GSI developed a framework for prioritizing drillhole decommissioning, in collaboration with the City of Bend, by calculating a risk score for each drillhole. The risk score was calculated for each drillhole location based on the following criteria: land use (Section 3.1.1), traffic volume (Section 3.1.2), risk to drinking water quality (Section 3.1.3), and current drillhole condition (Section 3.1.4). Each criterion was divided into different risk categories (e.g., high, medium or low), a score was assigned to each category, and a weighting was assigned to each score. Weighting was either applied as an "additive" (meaning the total risk score for a given drillhole is determined by summing the score for the criterion) or a "multiplier" (meaning the total risk score for a given drillhole is determined by multiplying the score for the criterion).

3.1.1 Land Use

Land use is correlated with pollutant load and likelihood of a hazardous material spill. Drillholes located in land use categories associated with higher pollutant loads and spill potential were prioritized for retrofit or replacement. Land use categories are shown in Table 3, and are classified into "high risk," "moderate risk," and "low risk" categories such that the highest risk is associated with the highest pollutant load and spill likelihood. The land use dataset is from the City of Bend Zoning Designations. Risk assigned to Land Use categories are shown on Figure 3.

Table 3. Risk Assigned to Land Use (City of North Bend, 2015; City of Bend, 2024).

<table>
<tr><th>Risk Category</th><th>City of Bend Zoning Designation</th><th>Definition</th><th>Score Assigned</th><th>Multiplier or Additive</th></tr>
<tr><td>High Risk</td><td>Industrial</td><td>Manufacturing and Production, industrial service, warehouse, transportation, freight, and distribution</td><td>3</td><td>Additive</td></tr>
<tr><td rowspan="4">Moderate Risk</td><td>Commercial</td><td>Retail, services, and offices</td><td rowspan="4">2</td><td rowspan="4">Additive</td></tr>
<tr><td>Mixed-Use</td><td>Residential land use with retail/commercial/office and/or service uses in the same building or on the same site.</td></tr>
<tr><td>Public Facility (AND >50% impervious[1])</td><td>Public facilities, including Town Hall, recycling center, Community parks, sports complexes (and other outdoor recreation)</td></tr>
<tr><td>Urban Area</td><td>Urban Growth Area, i.e. area that may be developed in the future but not yet determined what land use it will be developed to.</td></tr>
<tr><td rowspan="3">Low Risk</td><td>Public Facility (AND <50% impervious[1])</td><td><80% developed to just capture community parks, sports complexes (and other outdoor recreation)</td><td rowspan="3">1</td><td rowspan="3">Additive</td></tr>
<tr><td>Professional Office</td><td>"The Professional Office zone is intended to provide for professional offices in locations near arterial or collector streets and to provide a transition of uses between residential areas and other more intensive zones. Through design standards, the Professional Office zone is intended to create a mix of high density residential housing, office and service commercial developments that are pedestrian oriented and provide a positive contribution to the streetscape."</td></tr>
<tr><td>Residential</td><td>Low to high-density housing</td></tr>
</table>

Note:
[1]The 50% impervious threshold was used to ensure the Deschutes Recycling center was captured. This site is within the 'public facilities' layer but is a higher risk than other facilities including parks that predominantly made up this layer so this impervious threshold was added to weed out this and other potentially contaminating sites.

3.1.2 Traffic Volume

Traffic volumes are correlated with pollutant load to a UIC, such that higher traffic volumes result in a higher pollutant load due to higher brake pad wear, deposition of hydrocarbon combustion byproducts, etc. Drillholes located in higher traffic volume streets were prioritized for retrofit or replacement. Traffic volumes were prioritized under the assumption that certain road types are characterized by higher traffic volumes, and thus have a greater pollutant load entering UICs (City of Bend Transportation and Mobility, 2024). Data for this category came directly from the City, in a shapefile titled 'Road_Centerlines.' Risk categories that were assigned to Traffic Volume are outlined in Table and displayed on Figure 4.

Table 4. Risk Assigned to Traffic Volume.

Risk Category	Vehicle Trips Per Day	Road classes within this category	Score Assigned	Multiplier or Additive
High Risk	> 1,000 vehicle trips per day (TPD)	Highways; Major Arterials; Ramps	3	Additive
Low – Moderate Risk	<1,000 vehicle TPD	Collector; Local; Minor Arterial; Resource; Service	1	Additive

3.1.3 Risk to Drinking Water Quality

This risk posed by drillholes to drinking water quality was assessed by considering the distance between the drillhole and the nearest water well (i.e., whether a drillhole is located within the two-year time-of-travel zone or 500 feet of a water well) and the depth to groundwater. A time-of-travel zone is the volumetric extent of groundwater that is pumped by a drinking water well over a given time period. For example, the two-year time-of-travel zone represents the groundwater that is pumped by a drinking water well over two years. DEQ rules discourage construction of UICs within the two-year time-of-travel zone to minimize risk to groundwater quality. If a two-year time-of-travel zone has not been delineated for a well, then DEQ rules discourage construction of UICs within 500 feet of a water well. In addition to location relative to a water well, UICs pose a higher risk to drinking water quality in areas of shallow groundwater because there is not as much unsaturated soil to filter and remove pollutants from stormwater. Two areas of shallow groundwater have been identified in the City.

Water Well Locations

Drillholes that are located within a two-year time-of-travel zone or 500 feet of a water well were prioritized for retrofit or replacement. Water wells included in this category were municipal supply wells, irrigation wells, and domestic supply wells (GSI, 2022). Risk categories that were assigned are outlined in Table a and shown on Figure 5a. An extra high risk category was added with a large multiplier to ensure that any drillholes within 100 feet of a water well rose to the top of the prioritization list.

Table 5a. Risk Assigned to Water Well Locations.

Risk Category	Well Location	Score Assigned	Multiplier or Additive
Extra High Risk	<100 ft from water well	10	Multiplier
High Risk	<500 ft from water well	3	Additive
Low Risk	>500 ft from water well	1	Additive

An additional extra high risk category was added (Table 5b) with a large multiplier to ensure that any drillholes within Two-year time-of-travel of a public water well zones rose to the top of the prioritization list. This extra high risk category is shown in Figure 5b. There would be a very high impact if a public water well were to become contaminated due to the large population served.

Table 5b. Risk Assigned to Water Well Locations.

Risk Category	Well Location	Score Assigned	Multiplier or Additive
Extra High Risk	Two-year time-of-travel of a public water well zones	20	Multiplier

Groundwater depth

The depth to the regional groundwater table in Bend ranges from 300-750 feet bgs; however, areas of perched groundwater with groundwater depths of a few feet to 200 feet bgs have been identified within the City (GSI, 2024). These perched groundwater areas are primarily within two regions: the Old Mill District Perched Area and the North Bend Perched Area (Figure 5c). Based on the findings of GSI's 2024 Groundwater Protectiveness Demonstration Update, 53 ft vertical separation between the base of the UIC and the seasonal high of groundwater is required to protect groundwater from PFAS in stormwater (GSI, 2024). Because drillholes can be constructed to 100 feet deep, PFAS in stormwater discharges from drillholes has the potential to reach groundwater in these perched areas.

Drillholes located in areas of perched groundwater were prioritized for retrofit and/or replacement. These locations are shown in Figure 5c. Perched groundwater within the "North Bend Perched Area" or the "Old Mill

District Perched Area" has been applied as a multiplier due to the significant risk of introducing contamination to shallow groundwater posed by drillholes within these areas. Risk categories that were assigned to perched groundwater areas are shown in Table and on Figure 5c.

Table 6. Perched Groundwater within the "North Bend Perched Area" or the "Old Mill District Perched Area."

Risk Category	Vertical Separation from Groundwater/Perched Groundwater	Score Assigned	Multiplier or Additive
Extra High Risk	Areas of perched groundwater **AND** <53 ft vertical separation from groundwater	2	Multiplier
High Risk	Areas of perched groundwater	1.5	
Low Risk	Outside of a perched groundwater area	1	

3.1.4 Current Drillhole Condition

For this section, GSI reviewed the 'Stormwater Master Plan Flooding Locations' spreadsheet as well as the 'Stormwater Flooding Report' for City-owned drillholes, provided by Travis Somers of the City of Bend Stormwater Utility Department via email in April 2024. The 'Stormwater Master Plan Flooding Locations' spreadsheet identified UICs (both drywells and drillholes) with known flooding issues that the City is aware of. These were organized by the City by order of priority to replace or repair, with Priority 1 being the highest priority to address. The Stormwater Flooding Reports detailed known information about each site, along with photos. These are included in Appendix A and locations are shown on Figure 6. Risk categories that were assigned to current drillhole conditions are shown in Table . A multiplier was applied to drillhole conditions to ensure drillholes that have been pre-prioritized for replacement would float to the top of this prioritization list.

Table 7. Risk assigned to Current Drillhole Conditions.

Risk Assigned	Category	Definition[3]	Score Assigned	Multiplier or Additive
High Risk	Level 1 Priority	Stormwater causes or is at risk of causing safety concerns. Stormwater causes property damage or has the risk of causing property damage. Frequent responses from the City are required.	3	Multiplier
Moderate Risk	Level 2 Priority	Stormwater infrastructure may be undersized or failing. Less frequent responses from the City are required, often after a more sustained rain event	2	
Low Risk	Level 3 Priority	Low priority locations. Some improvements completed at most of these sites to improve/control runoff. These locations should be evaluated overtime to decide if existing infrastructure is adequate, needs to be replaced, or additional controls are needed to increase capacity.	1	

3.2 Drillhole Decommissioning Prioritization Results

A score was assigned to each drillhole at the end of this scoring exercise. The results of the drillhole prioritization scoring assessment are shown on Figure 7. On this figure, drillhole rankings from 1 to 10 and >10 are displayed, with the drillhole ranked as number one being the drillhole that has the highest priority for replacement. The top five ranked drillhole prioritization results are shown in Table 8. The full drillhole scoring is shown in Appendix B.

[3] Provided by Travis Somers at the City of Bend via email on March 21, 2024

Table 8. Drillhole Decommissioning Prioritization Results.

Priority Rank	Drillhole ID(s)
1	DDH009510, DDH009485, DDH009498, DDH009625, DDH009624, DDH009514, DDH009513, DDH009550, DDH009520, DDH009841, DDH009727, DDH009728, DDH009767, DDH009766, DDH009764, DDH009765, DDH009763
2	DDH009875, DDH009932
3	DDH010013, DDH009573, DDH009572, DDH009571, DDH009396, DDH009397, DDH009394, DDH009444, DDH009431, DDH002022, DDH009122, DDH009129, DDH009130, DDH009586, DDH009585, DDH009583, DDH009446, DDH009447, DDH009438, DDH009419, DDH009420, DDH009403, DDH009425, DDH002020, DDH002049, DDH009407, DDH009406, DDH009405, DDH009404, DDH009416, DDH009426, DDH009423, DDH009424, DDH009440, DDH009441, DDH009436, DDH009437, DDH009417, DDH009418, DDH009392, DDH009386, DDH001022, DDH001023, DDH001013, DDH001012, DDH009398, DDH009439, DDH009395, DDH009421, DDH009422, DDH009482, DDH009443, DDH009381, DDH009384, DDH009380, DDH009385, DDH001015, DDH001014, DDH009399, DDH009415, DDH009412, DDH009413, DDH009628, DDH009629, DDH009632, DDH009604, DDH002018, DDH002019, DDH009445, DDH009387, DDH009388, DDH009389, DDH009390, DDH009391, DDH009393, DDH009402, DDH009401, DDH009400, DDH009429, DDH009430, DDH009435, DDH009434, DDH009433, DDH002023, DDH009428, DDH009631, DDH009630, DDH009605, DDH009603, DDH009609, DDH009606
4	DDH009902, DDH009863, DDH010018, DDH010019
5	DDH009454

4. References

Arizona Department of Environmental Quality (ADEQ). 2018. Guidance for Design, Installation, Operation, Maintenance and Inspection Of DRYWELLS.

Central Oregon Intergovernmental Council (COIC). 2010. Central Oregon Stormwater Manual.

City of Bend. 2012. Systemwide Assessment for the City of Bend Class V Stormwater Underground Injection Control Systems.

City of North Bend. 2015. City of North Bend Comprehensive Plan 2015. Available at: https://northbendwa.gov/238/Comprehensive-Plan

City of Bend. 2023. Standards and Specification. Available at: https://www.bendoregon.gov/government/departments/engineering/standards-and-specifications

City of Bend. 2024. City of Bend Zoning Designations. Available at: https://data.bendoregon.gov/datasets/bendoregon::zoning-1/about

City of Bend. 2024. Bend Code, Chapter 10.10, ‘Development Code’. Available at: https://www.bendoregon.gov/government/city-codes

City of Bend Transportation and Mobility. 2024. Bend’s Transportation System Plan (TSP), ‘TSP Roads.’ Available at: https://www.arcgis.com/home/item.html?id=b58c6e91aa064b1183fd80d30304ea09

City of Portland. 2024. Drywells. Available at: https://www.portland.gov/bes/stormwater/managing-rain-your-property/drywells Accessed May 22, 2024.

Geosyntec. 2020. California Drywell Guidance Research and Recommendations, prepared for: California Water Resources Control Board. March 31, 2020.

GSI. 2011. Pollutant Fate and Transport Model Results in Support of the City of Bend UIC WPCF Permit – Groundwater Protectiveness Demonstration and Proposed EDLs. September 21.

GSI. 2020. City of Bend Stormwater Infiltration Evaluation Update.

GSI. 2022. Drinking_Water_Wells. Available at: https://www.arcgis.com/home/item.html?id=a10c679035544988a65ba33237256f7d&sublayer=0

GSI. 2023. System-Wide Assessment, Individual WPCF Permit for Class V Underground Injection Control Systems, Permit No. 103052. March 27.

GSI. 2024. Groundwater Protectiveness Demonstration Update for Per- and Polyfluoralkyl Substances (PFAS), City of Bend, Oregon.

Jurries, D. and Ratliff, K. 2013. Industrial Stormwater Best Management Practices Manual. Oregon Department of Environmental Quality (DEQ)

Radford, S, 2016. Managing Stormwater With Green Infrastructure. PNCWA Newsletter, Spring.

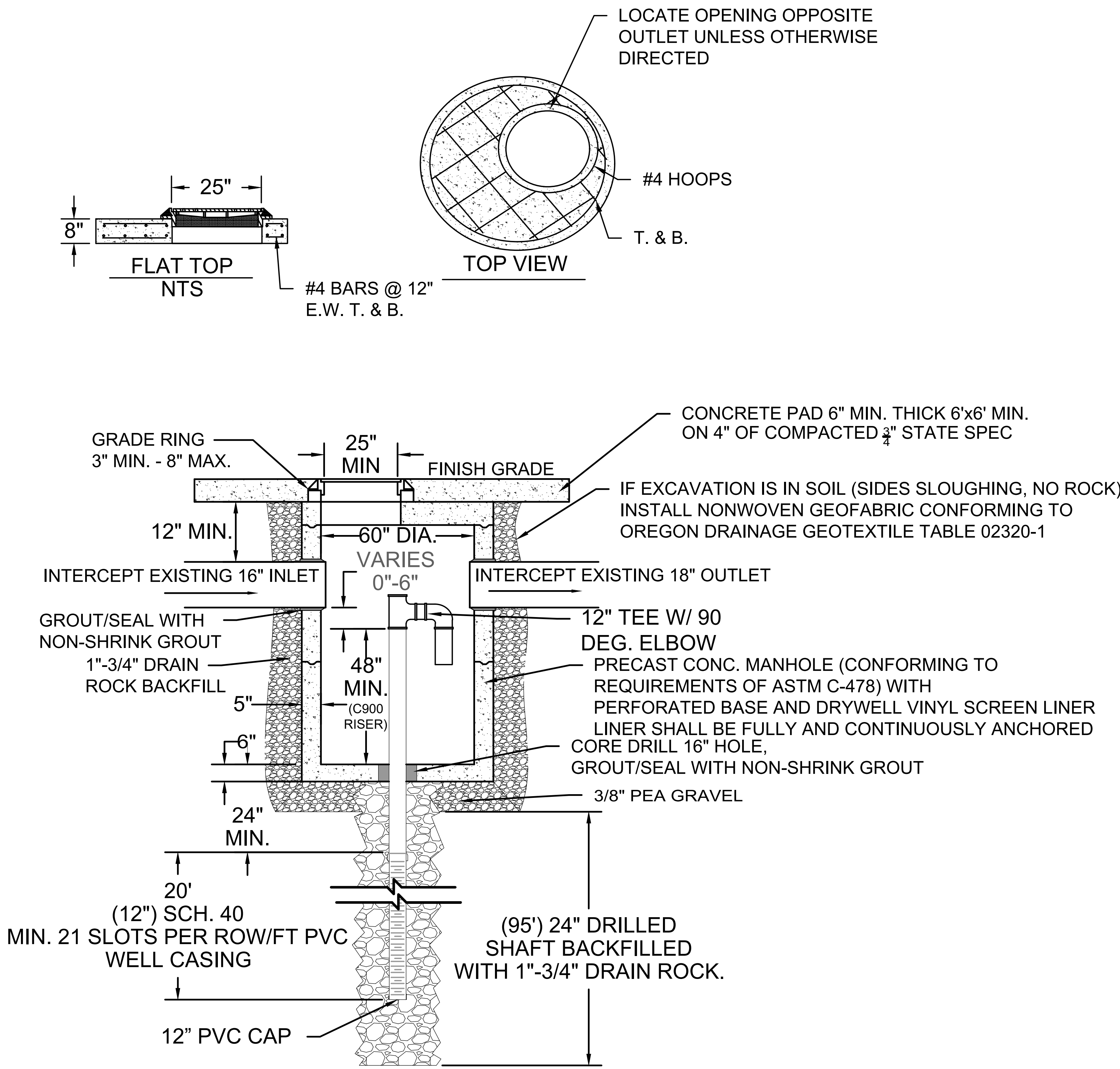
Sasidharan, S., Bradford, S. A., Šimůnek, J., Jong, B. D., and Kraemer, S. R. 2018. Evaluating drywells for stormwater management and enhanced aquifer recharge

Torrent Resources. 2015. Meeting the Requirement for Stormwater Infiltration. Available at: https://websites.pmc.ucsc.edu/~afisher/post/drywell/Torrent/TorrentDrywellPres_Watsonville150401.pdf

FIGURE 1

Deep Drywell Design for Overflow at Awbrey Reservoir

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework



1 G8.0 DEEP DRYWELL DETAILS

NTS

NOTES

This example was provided by the City of Bend

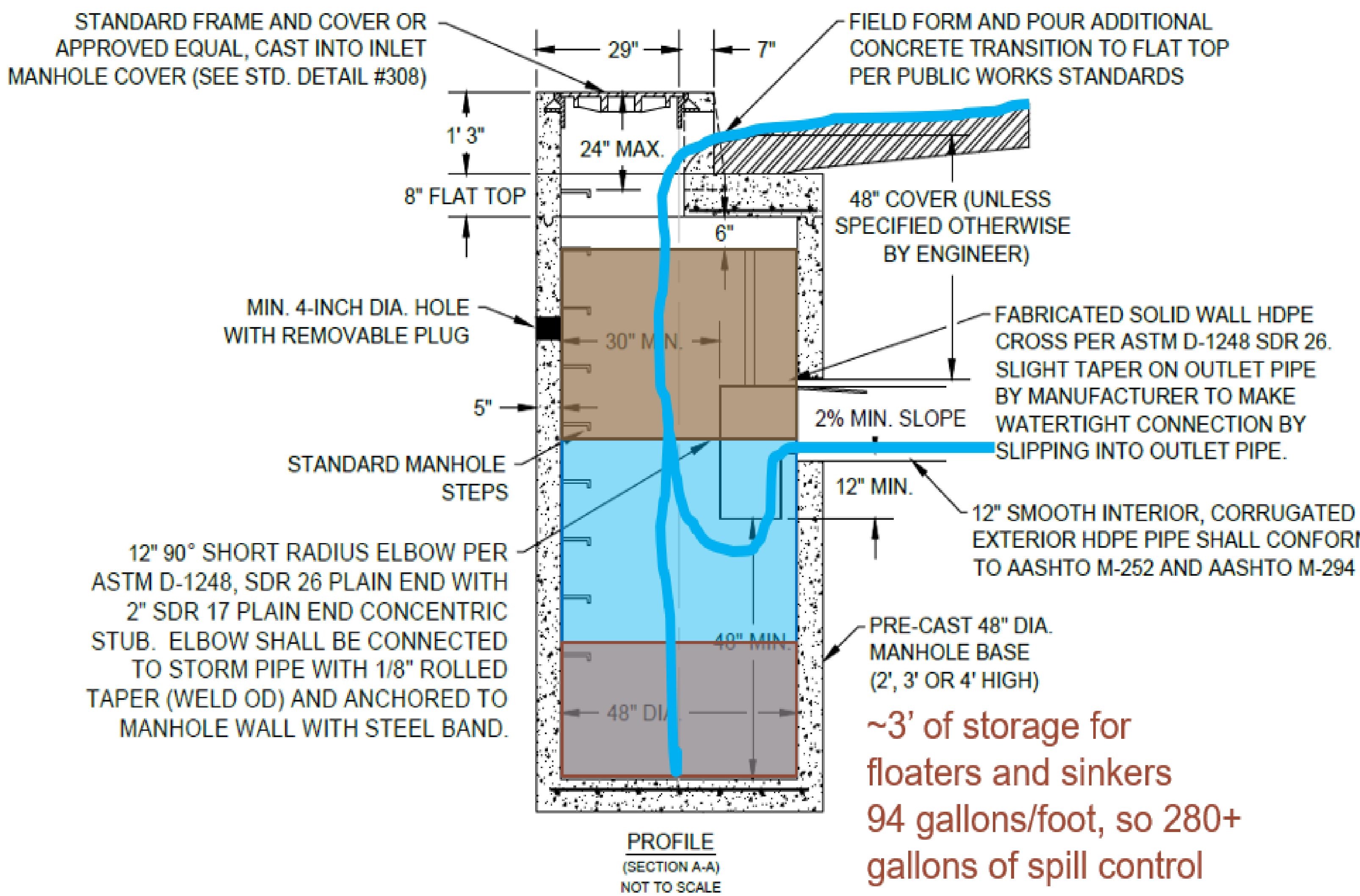
GSI Water Solutions, Inc.

Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting

FIGURE 1

Gresham Example

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework



1 NON-GRATED INLET SPILL CONTROL MANHOLE

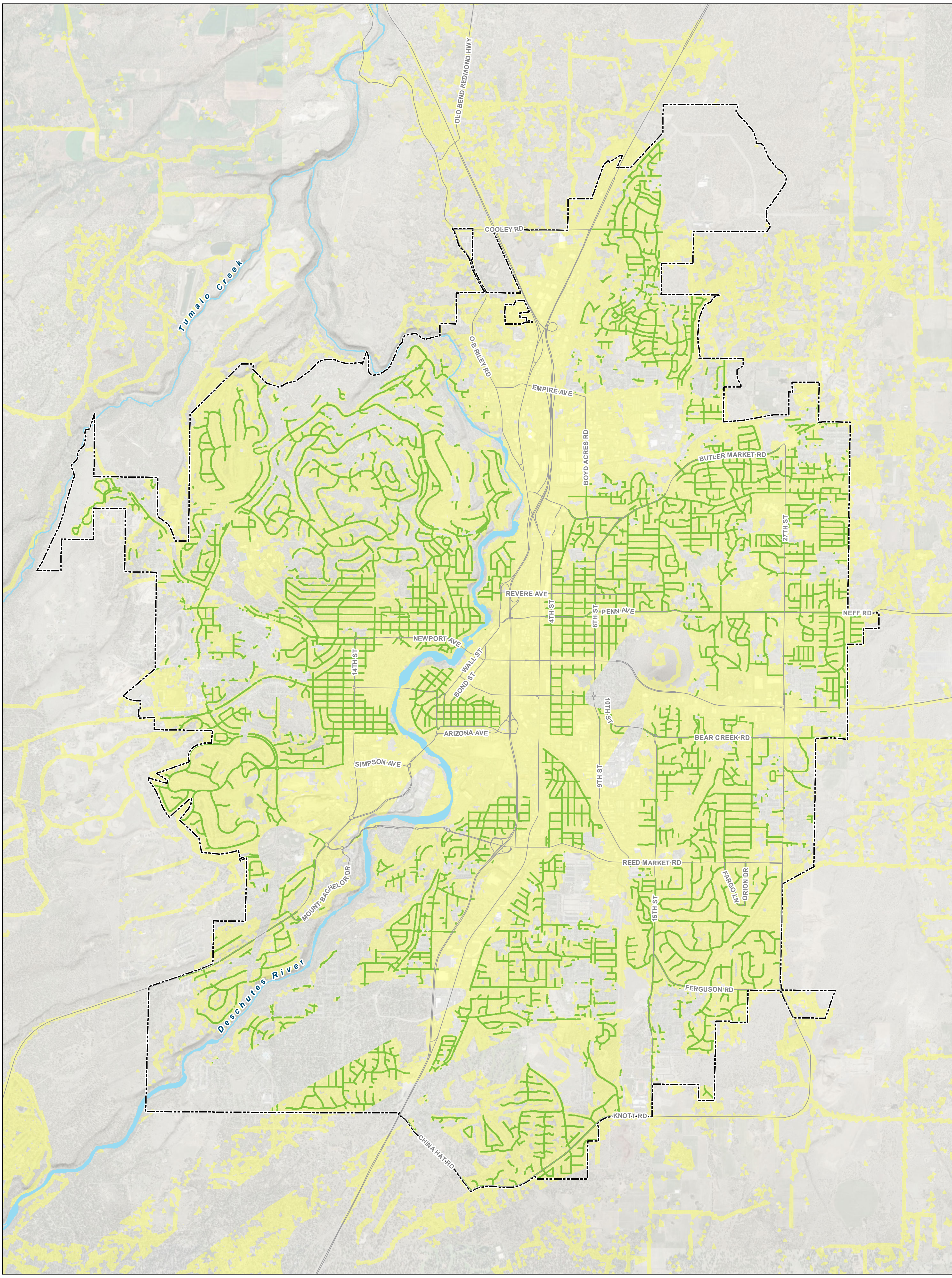
NOT TO SCALE

NOTES

This spill control manhole example was provided by the City of Gresham

GSI Water Solutions, Inc.

Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting



LEGEND

Green Light - Impervious surfaces, residential land use, streets that experience less than 1,000 vehicle trips per day, outside of two-year time-of-travel zones and <500 ft from water wells, and outside of areas with perched groundwater

Yellow Light - Impervious areas that are outside of the two-year ToT and greater than 100 feet from all water wells

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 2

Areas that Meet Siting Criteria

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

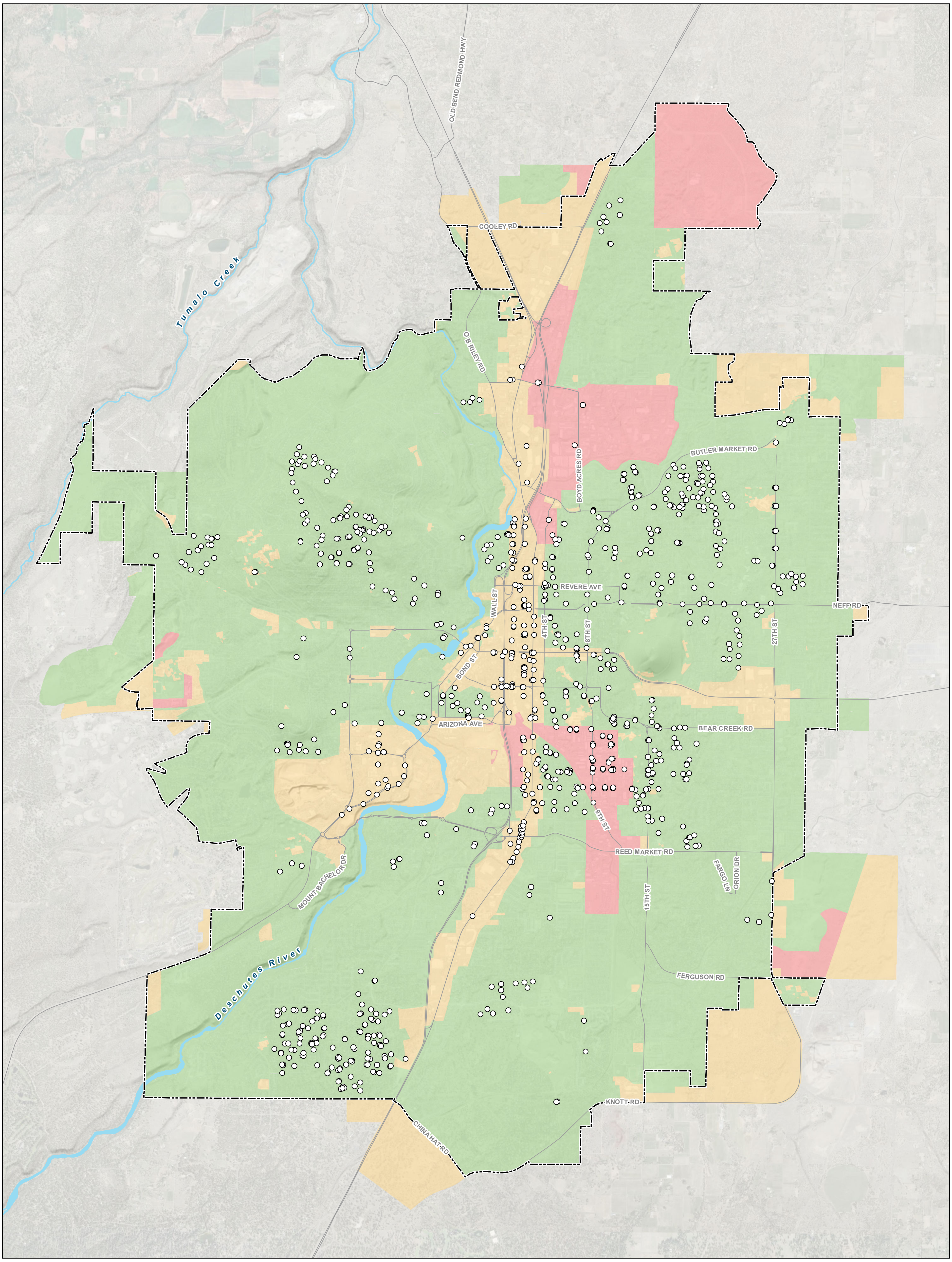
Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure2_Siting_Criteria.mxd, npalmer



LEGEND

○ Drillhole

Land Use Risk

- High Risk: Industrial
- Moderate Risk: Commercial, Mixed-Use, Public Facility (AND >50% Impervious), Urban Area
- Low Risk: Public Facility (AND <50% impervious), Professional Office, Residential

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 3

Land Use

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

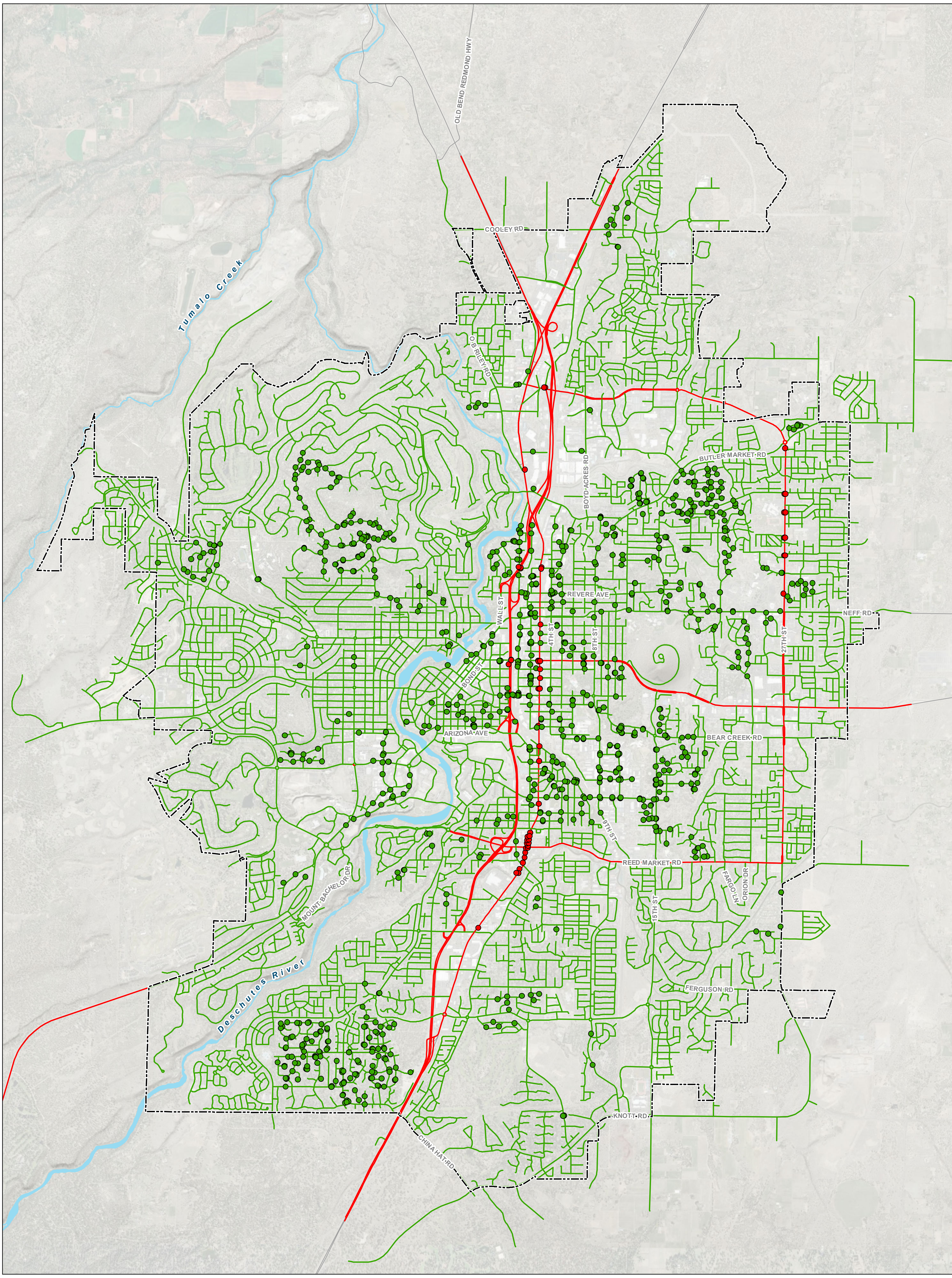
Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure3_Land_Use.mxd, npalmer



LEGEND

Drillhole

- High Risk
- Low-Moderate Risk

Traffic Volume Risk

- High Risk: >1,000 Trips per Day
- Low-Moderate Risk: <1,000 Trips per Day

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 4

Traffic Volume

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

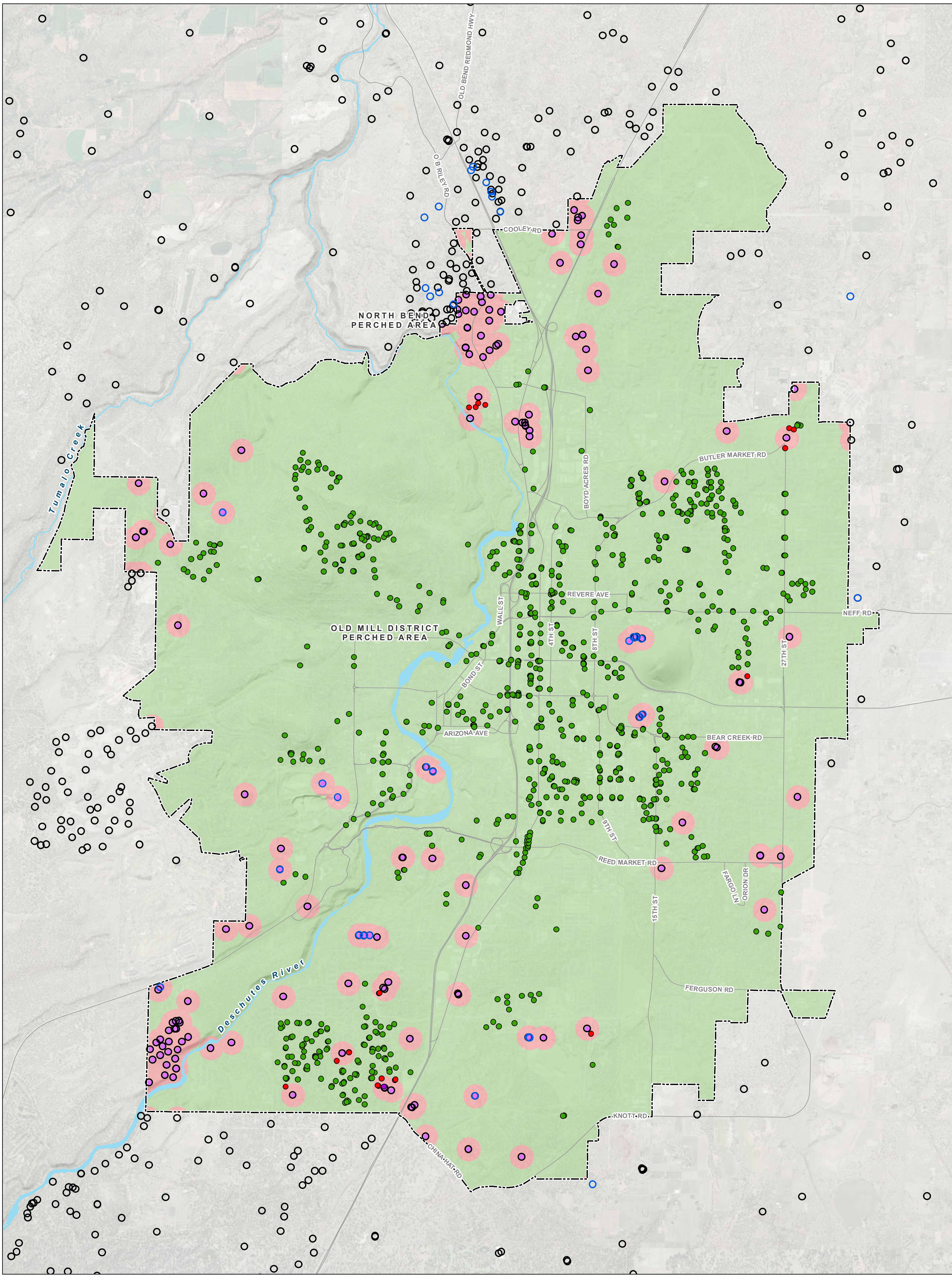
Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure4_Traffic_Volume.mxd, npalmer



LEGEND

- Drillhole
- Private Water Well
- Public Water Well

Risk Assigned to Water Well Locations

- Extra High Risk: <100 ft from water well
- High Risk: <500 ft from water well
- Low Risk: >500 ft from water well

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 5a

Risk Assigned to Water Well Locations – Distance from Water Wells

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

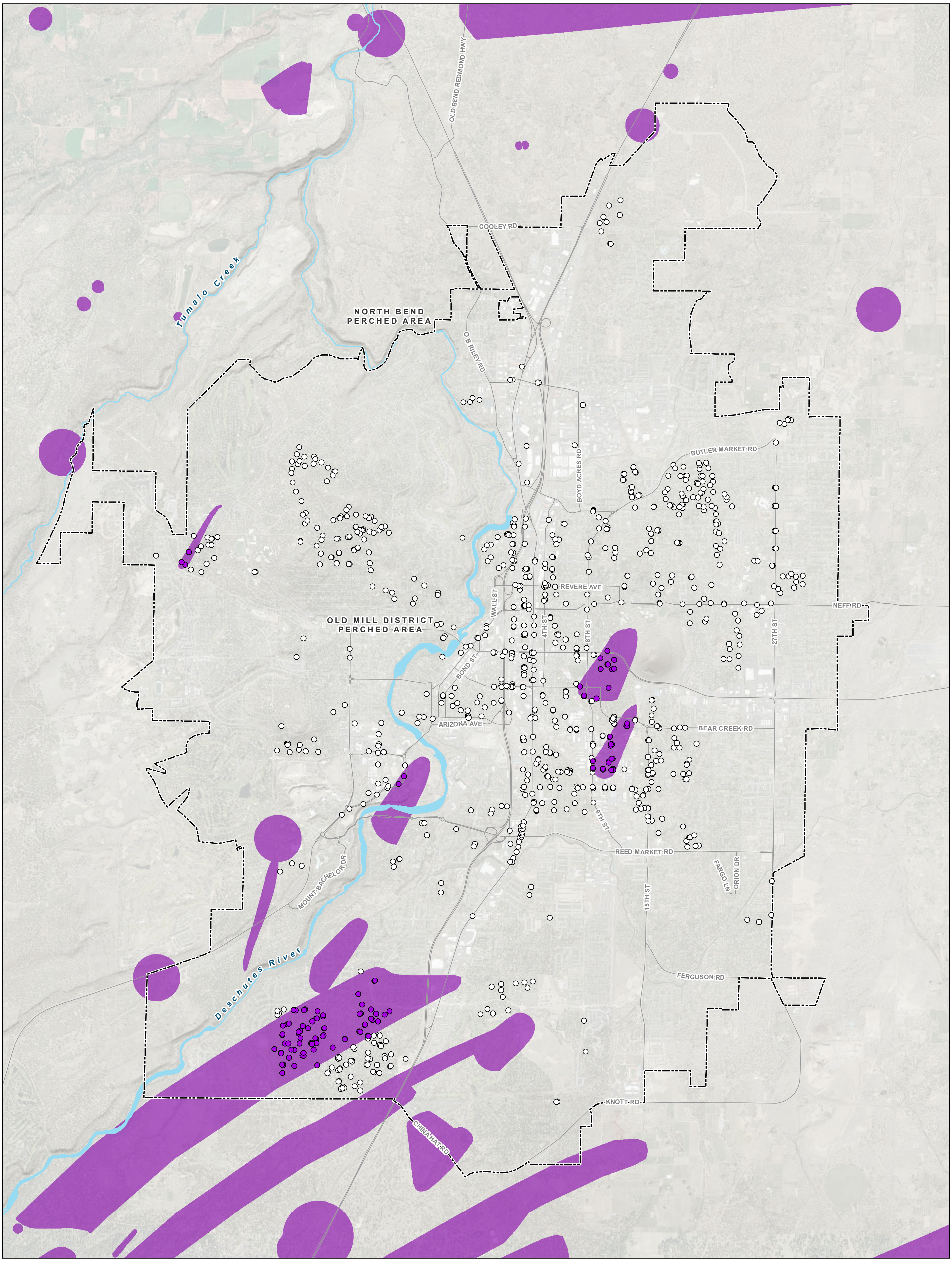
Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure5a_Distance_Water_Wells.mxd, npalmer



LEGEND

- Drillhole
- Extra High Risk: Two-year time-of-travel of a public water well zones

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 5b

Risk Assigned to Water Well Locations – Risk to Public Water Wells

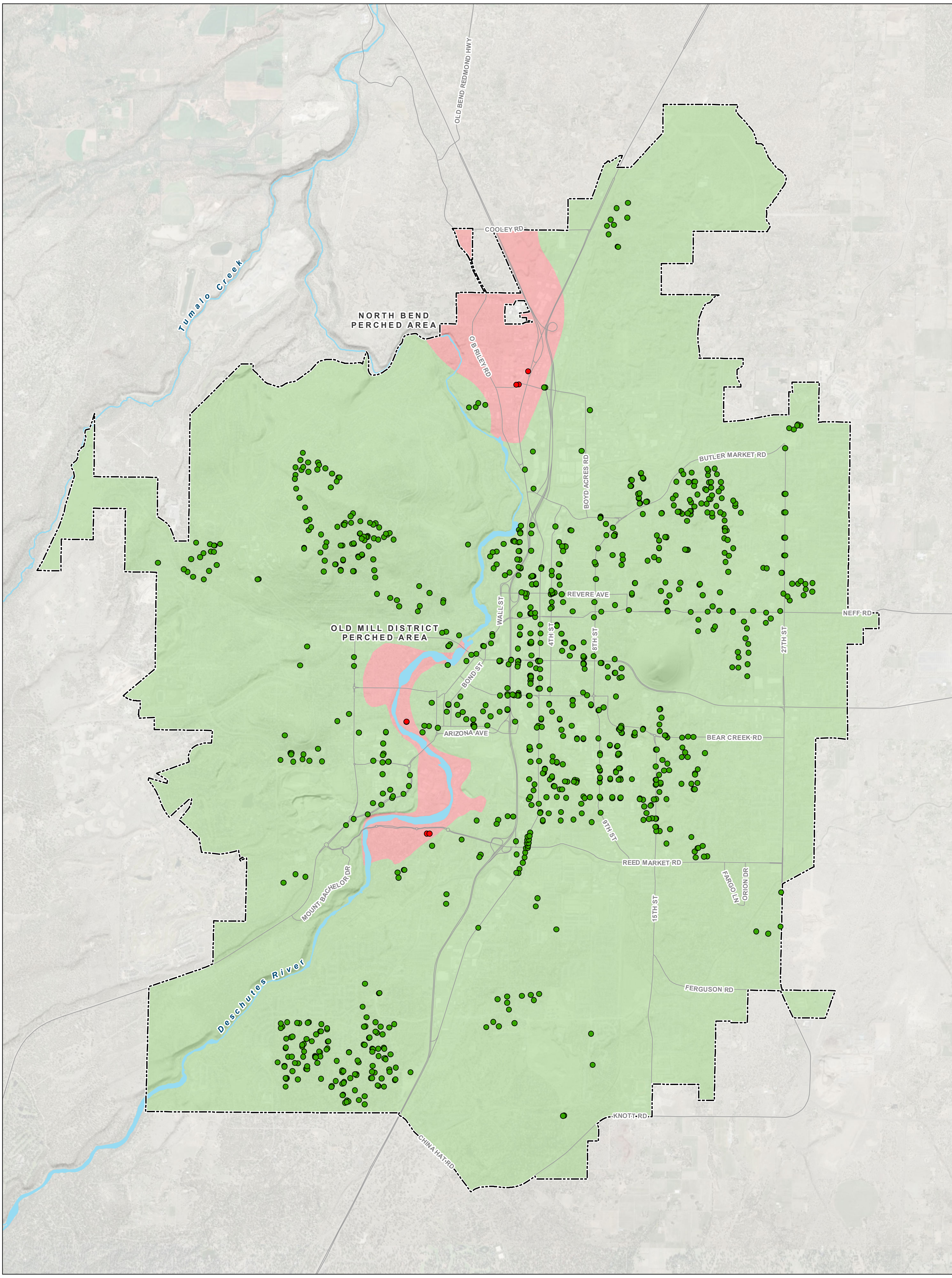
City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.



LEGEND

○ Drillhole

Risk Assigned to Water Well Locations

Low Risk: Outside of a perched groundwater area

High Risk: Areas of perched groundwater

Extra High Risk: Areas of perched groundwater AND <53 ft vertical separation from groundwater

All Other Features

City Boundary

Major Road

Watercourse

Waterbody

FIGURE 5c

Risk Assigned to Water Well Locations - Perched Groundwater within the "North Bend Perched Area" or the "Old Mill District Perched Area

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

Date: July 3, 2024

Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

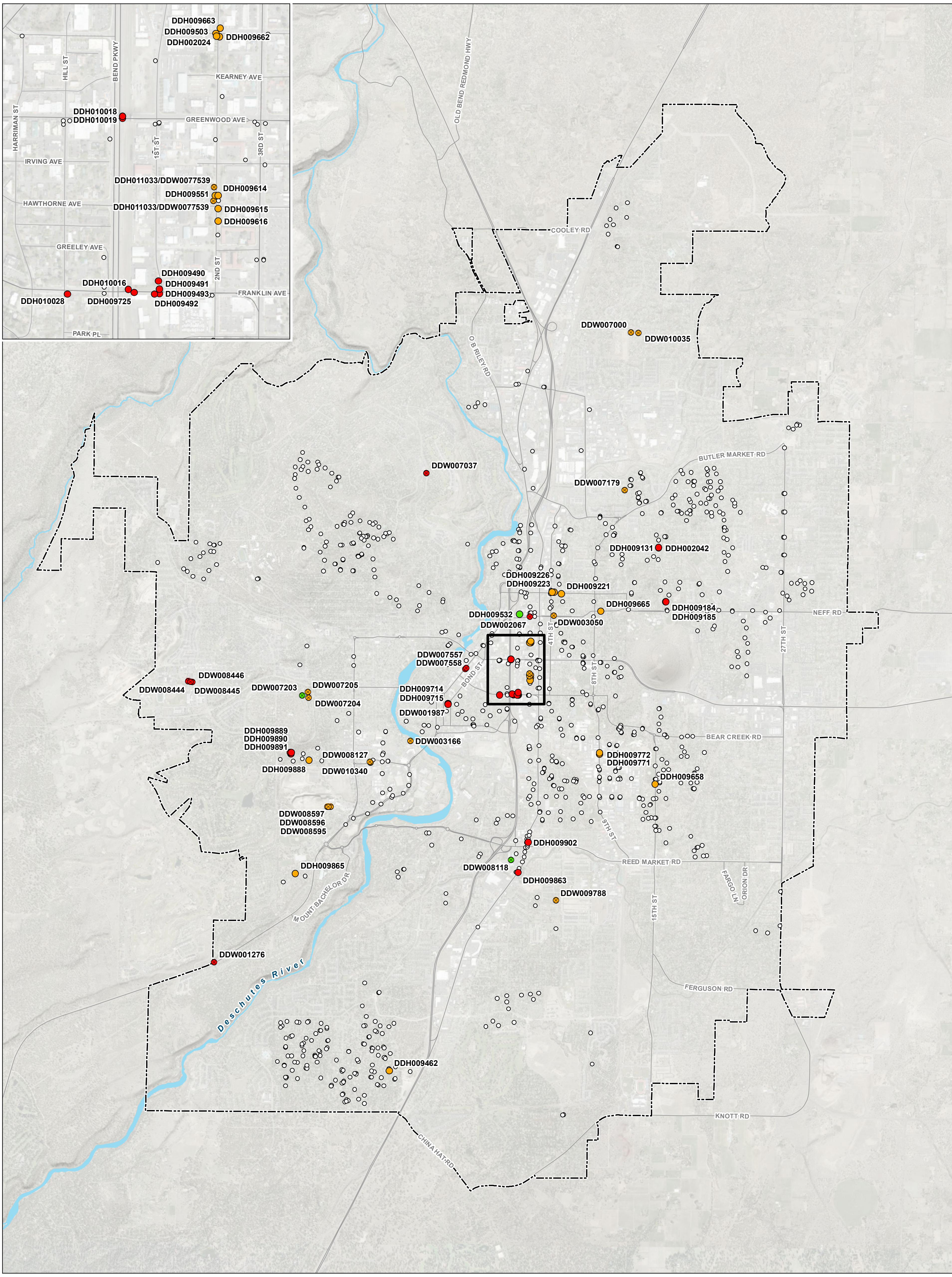
N

0 2,000 4,000 6,000

Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure5c_Perched_GW.mxd, npalmer



LEGEND

- Drillhole
- Dry Well

Risk Level Priority

- High Risk: Level 1
- Moderate Risk: Level 2
- Low Risk: Level 3

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 6

Current Drill Hole Conditions

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

Date: July 3, 2024

Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

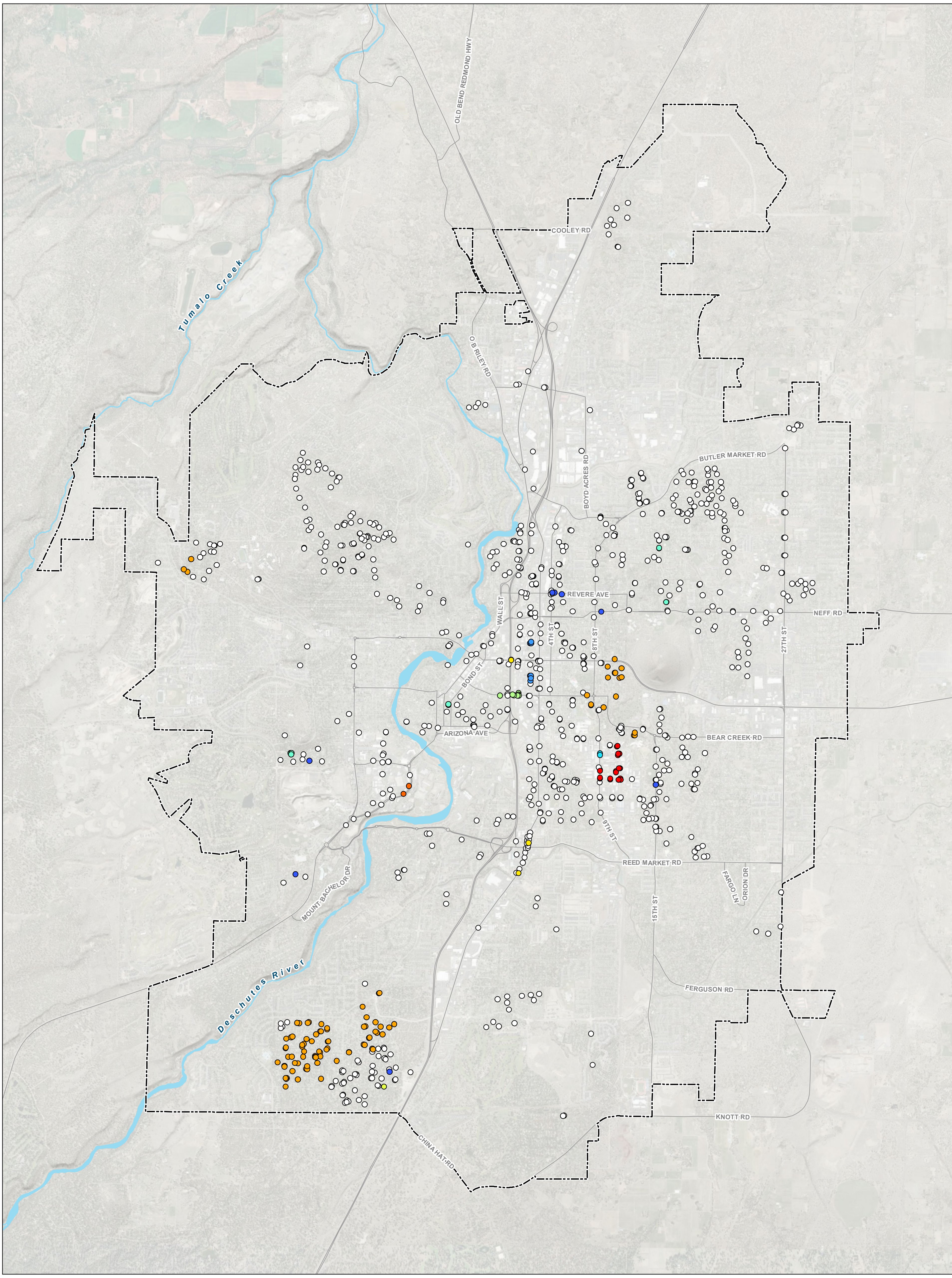
N

0 2,000 4,000 6,000

Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure6_Current_Drill_Hole.mxd, npalmer



LEGEND

Drillhole Priority Rank (Quantity)

- 1 (17)
- 2 (2)
- 3 (91)
- 4 (4)
- 5 (1)
- 6 (7)
- 7 (9)
- 8 (2)
- 9 (8)
- 10 (9)
- >10 (960)

All Other Features

- City Boundary
- Major Road
- Watercourse
- Waterbody

FIGURE 7

Priority Ranking

City of Bend Modified Drywell Siting Criteria and Drillhole Decommissioning Framework

Date: July 3, 2024
Data Sources: City of Bend, ESRI, ODOT, USGS, Aerial Photo 2022

N

0 2,000 4,000 6,000
Feet

GSI Water Solutions, Inc.

Document Path: Y:\0655_Otak\Source_Figures\004_Bend_SW_Master_Plan\Modified_Drywell_Siting\Figure7_Priority_Ranking.mxd, npalmer