# Contents

1 Introduction...................................................................................................................... 4  
1.1 Definitions ...................................................................................................................... 4  

2 Submittal Requirements .................................................................................................. 5  
2.1 Design Phase Submittals................................................................................................. 5  
2.2 Schedule ........................................................................................................................ 5  

3 Parking Functional Design............................................................................................... 5  
3.1 Site................................................................................................................................. 5  
3.2 Parking Geometrics ........................................................................................................ 6  
3.3 Driveways / Stacking ...................................................................................................... 7  
3.4 Americans with Disabilities Act (ADA) ............................................................................. 8  
3.5 Ramp Slopes.................................................................................................................. 8  
3.6 Striping ........................................................................................................................... 8  
3.7 Parking Access and Revenue Control Systems (PARCS) ............................................... 8  

4 Structural......................................................................................................................... 9  
4.1 Building Codes and Standards........................................................................................ 9  
4.2 Structural Systems ......................................................................................................... 9  
4.3 Durability ...................................................................................................................... 10  
4.4 Vertical Clearances ...................................................................................................... 11  
4.5 Volumetric .................................................................................................................... 11  

5 Architectural .................................................................................................................. 11  
5.1 Façade.......................................................................................................................... 11  
5.2 Future Expansion ......................................................................................................... 12  
5.3 Elevators ..................................................................................................................... 12  
5.4 Stairs............................................................................................................................ 13  
5.5 Signage and Wayfinding ............................................................................................... 13  
5.6 Bicycles ......................................................................................................................... 14  
5.7 Railings ........................................................................................................................ 14  
5.8 Waterproofing .............................................................................................................. 14
5.9 Rooms.......................................................................................................................... 15
5.10 Doors and Hardware.................................................................................................. 15
5.11 Equipment.................................................................................................................. 15
6 Electrical...................................................................................................................... 16
  6.1 Lighting .................................................................................................................... 16
  6.2 Power Distribution .................................................................................................. 16
7 Plumbing...................................................................................................................... 17
  7.1 Drainage .................................................................................................................. 17
  7.2 Piping ....................................................................................................................... 17
  7.3 Hose Bibs.................................................................................................................. 18
  7.4 Pipe Protection ........................................................................................................ 18
  7.5 Code Review............................................................................................................ 18
8 Fire Protection............................................................................................................. 18
9 Mechanical................................................................................................................... 18
10 Safety and Security ................................................................................................... 19
  10.1 Crime Prevention Through Environmental Design (CPTED)................................. 19
  10.2 Blue Phones / CCTV.............................................................................................. 19
  10.3 Data / Building Information Systems ..................................................................... 19
11 Sustainability.............................................................................................................. 19

APPENDIX A - Conceptual Drawings
APPENDIX B - Preliminary Geotechnical Investigation
APPENDIX C - Novus Innovation Corridor Master + Design Standards (March 2018)
APPENDIX D - Novus Innovation Corridor Streetscape Design Manual (March 2018)
1 INTRODUCTION

This document has been prepared to assist Arizona State University (ASU) in the development of a high-quality parking facility. The purpose of the Design and Performance Criteria for Parking Structures is to provide guidance regarding design standards, operational practices, technology integration, and maintenance requirements to support requirements of ASU in selection of a design-build contractor for this project.

The base project should provide a Phase 1 1,250 space precast parking structure with the following components further defined in the criteria:

- Must be designed to be horizontally or vertically expanded to 2,200 spaces.
- Must have 30% enhanced façade coverage.
- Must fit on the defined building site.
- Must construct the shared access drive as indicated in the Conceptual Drawings (provided in Appendix A).
- Must accommodate and maintain parking and pedestrian access to the Phase 1 parking structure while the Phase 2 expansion and future buildings are constructed.
- Must provide stormwater detainage on site.
- Must accommodate future skybridge to ISTB7.
- Must be no taller that the planned surrounding buildings.
- Must attain Parksmart Certification through the Green Business Certification, Inc. (GBCI)

The following enhancements should be incorporated (in order of importance) as the project budget allows:

- Additional façade coverage/material enhancements.
- Speed ramps in lieu of parkable ramps.
- A basement level with areaway (maintaining an S-2 open parking garage) to limit height and massing.
- The ability to covert approximately 13,000 SF of ground level parking area to future retail space.
- Painting/staining of all parking area ceilings white.

1.1 DEFINITIONS

- **Arizona State University** (ASU) is the Owner of the project.
- **Design-Builder** is the firm or firms that have a contract with ASU to construct the project.
- **Designer** is the firm or firms of architects and/or engineers that have a contract with the Design-Builder for the project.
- **Project Manager** (PM) is the Owner’s Representative and/or ASU Representative assigned to the project.
2 SUBMITTAL REQUIREMENTS

2.1 DESIGN PHASE SUBMITTALS

Design drawings, specifications, and initial and final guaranteed maximum price (GMP) construction costs should be submitted to ASU on the following schedule:

- Schematic Design – 30%
- Design Development – 60%
- Construction Documents – 100%

The intent of these submittals is for ASU to review the progress of design, provide review comments regarding the design, and review the GMP for the project. The design team should not proceed onto the next design phase until receiving approval from ASU.

2.2 SCHEDULE

A detailed Schedule of design and anticipated construction shall be submitted to ASU for review during the Schematic Design Phase, and updated during each subsequent design phase. The Schedule should consider durations including critical path and perquisite tasks for each required design phase and permitting phase, and include appropriate review time by ASU. Key milestones should be identified.

3 PARKING FUNCTIONAL DESIGN

3.1 SITE

a. The project should fit on the proposed site with setbacks as indicated by the Conceptual Drawings (provided in Appendix A).

b. The shared access drive bisecting the property line to the west should be constructed as part of this project as indicated on the Conceptual Drawings (provided in Appendix A).

c. Underground stormwater storage detainage providing 100,500 cubic feet shall be incorporated into the structure footprint under the basement level via cast-in-place vaults, interlocking concrete culverts or interlocking concrete pipe or half pipes. No corrugated metal pipe (CMP) shall be used for stormwater detention. It is anticipated that stored stormwater will infiltrated into the site using dry gravel beds or ground wells in the required time.

d. A dumpster enclosure should be provided with three (3) locations for zero waste and one (1) compactor.

e. Overall design should be provided per the Novus Innovation Corridor Master + Design Standards (March 2018) (provided in Appendix C).

f. Landscaping should be provided per the Novus Innovation Corridor Streetscape Design Manual (March 2018) (provided in Appendix D).

g. Refer to ASU Project Guidelines 11 82 26 Refuse Compactors.
h. Refer to ASU Project Guidelines Division 31 Earthwork.

i. Refer to ASU Project Guidelines Division 32 Exterior Improvements and 32 90 00 Landscaping.

### 3.2 PARKING GEOMETRICS

a. Provide a minimum of 1,250 parking spaces.

b. The parking structure should be designed to be vertically or horizontally expandable in the future to accommodate 2,200 spaces.

c. Standard Spaces: The standard spaces in the parking structure may be designed using 90-degree orientation for two-way drive aisles, or 60-degree to 70-degree orientation for one-way drive aisles.

   i) Minimum Stall Width = 9'-0" (90-degree space orientation measured perpendicular to the stripe). 60-degree to 70-degree space orientation may be used in limited conditions as determined by the final design configuration.

   ii) Stall Length = 18'-0" long (90-degree space), 18'-9" long (60-degree space), 19'-0" (70-degree space) measured perpendicular to the drive aisle

d. Compact Spaces: Minimum width = 7'-6", Minimum length = 14'-0"

   i) Up to 5% of parking may be sized and designed for compact spaces.

   ii) No more than 10 compact spaces may be located consecutively.

e. Aisle Widths: Minimum drive aisle width shall be 24'-6" for two-way drive aisles with 90-degree spaces, 14'-6" for one-way 60-degree spaces, and 16'-6" for one-way 70-degree spaces. Spaces shall otherwise be in compliance with the local zoning ordinance requirements.

   i) Designer may reduce aisle width 3 inches for each additional 1 inch of stall width.

   ii) Minimum stall width may not be reduced for increased aisle width.

f. Turning Bay Width: End bay turning movements shall have 26'-6" minimum between face of obstruction or back of parking space.

g. Accessible stalls and access aisles shall comply with current ADA standards.

h. Electric vehicle spaces:

   i) Provide a minimum of 20 electric vehicle spaces with dual-head charger units distributed on all parking levels.
ii) Provide electrical infrastructure (including but not limited to dedicated transformer, circuit breakers, and primary electrical feeds) necessary for a future conversion of approximately 25% of total parking spaces to support electric charger units.

iii) Suitable, clear access space must be provided around the charging station to allow users to operate the equipment.

iv) At least one (1) electric vehicle charging space must be designated ADA accessible. Parking space layouts must include space widths and access aisles in accordance to ADA requirements, and the equipment must be provided to meet accessibility standards. The EV-ADA space does not count towards the minimum number of ADA spaces required by code.

i. Provide structural and parking layout to minimize the inclusion and impact of columns in the parking spaces. Columns, pipe guards and risers shall not unduly encroach into parking spaces, except as allowed by the local zoning ordinance or a maximum 1'-0” encroachment (2'-0” maximum per parking module) for 30% of the spaces.

   i) Should a design condition result in a vertical element to be located within the parking module, the minimum space width should be increased by 12” to account for increased maneuverability.

j. It is recommended that long span column grids be utilized, where possible.

k. Parking structure should be designed to efficiently maximize parking with the least amount of unused space with respect to elements such as columns, parking bays, ramp lengths, storage rooms, stairs, elevator rooms, “dead corners”, and other features.

l. Minimize the use of wheel stops to reduce tripping hazards; no wheel stops are preferred.

   i) If wheel stops are used they should be painted the same color as the bollards.

m. Refer to ASU Project Guidelines 12 93 00 Site and Mall Furnishings.

### 3.3 DRIVEWAYS / STACKING

a. Designer should perform a queuing analysis to determine number of entry and exit lanes required for the facility.

b. Pedestrian and vehicle conflicts at ingress/egress points shall be minimized. Dedicated walkways should be provided so that the vehicular entry and exit lanes are not readily used by pedestrians.

c. Entrances shall conform to local ordinance standards regarding sight lines, ramp incline, driveway aprons, and any other visibility issues affecting the driver or pedestrians.

d. Stacking space:
i) Stacking space is defined as the distance from the parking access control equipment gate arm back along the vehicular driveway.

ii) Minimum stacking size = 20'-0".

iii) On or off-site traffic movements or pedestrian movements shall not be impeded within the stacking space distance. This includes, but is not limited to, the street right-of-way, sidewalks outside of the parking structure, and pedestrian egress routes within the parking structure.

3.4 AMERICANS WITH DISABILITIES ACT (ADA)

a. The parking structure shall meet all applicable federal ADA and local accessible regulations.

b. Accessible routes must be provided to allow safe movement between the parking structure and the egress exits.

3.5 RAMP SLOPES

a. Parkable ramps with striped parking spaces shall target a maximum slope = 6%.

b. Express ramps must be designed to minimize dangerous encounters between vehicles and pedestrians. Maximum express ramp slope = 12%.

c. Where adjacent slopes exceed 8%, provide transition ramps.

d. Ramp slopes along accessible routes shall not exceed 1:48 (2.08%) in any direction.

3.6 STRIPING

a. Pavement markings should be a minimum two coats of traffic and zone marking paint.

b. All pavement markings, unless otherwise required by code, shall be white.

c. Faces and the top 6” of curbs should be painted yellow to minimize tripping hazard liability.

3.7 PARKING ACCESS AND REVENUE CONTROL SYSTEMS (PARCS)

a. Rough-ins for the PARCS equipment are to be consistent with ASU equipment in other parking facilities. Public parking should accommodate a paid operation using a ticket dispenser on entry and payment to a pay-on-foot station and exit station within the exit lane.

b. Design shall be set up to accommodate installation of equipment provided by the Design-Builder and installed by the Design-Builder using ASU’s approved vendor. This includes, but not limited to, curbs, islands, conduits, rooms, etc. Future equipment may be added accessing the basement level and other areas defined in the plan development. Lane dimensions and system design will be per ASU standards.
c. If a lane is designated as a dual entry/exit, the design should include installation of LED X/Arrow signs mounted above the entry and exit lanes signifying which lanes are open or closed.

d. Design shall accommodate the installation of gate arms, safety loops, and ticket dispensers at entrances.
   i. Preference will be to have barrier gates placed so straight-arm gates can be used.

e. Design shall accommodate the installation of gate arms, safety loops, and pay-in-lane credit card at each exit lane.

f. No attendant booths should be provided.

4 STRUCTURAL

4.1 BUILDING CODES AND STANDARDS

a. Comply with Federal, State, Local, and Industry codes, standards, and regulations in the design and construction of the parking structure. When codes conflict, the most stringent code shall govern.

b. Design in accordance with the International Building Code, most recent edition (2018) with all amendments.

c. All elements must conform to the Federal Public Law 101-336, known as the “Americans with Disabilities Act” which adopted the 2010 ADA Standards for Accessible Design.

d. Design and construction shall follow requirements of the March 2018 Revision of ASU Design Guidelines (can be found at [www.asu.edu/purchasing/forms/design_guidelines.pdf](http://www.asu.edu/purchasing/forms/design_guidelines.pdf)).

4.2 STRUCTURAL SYSTEMS

a. Foundations: A subgrade exploration should be conducted by a Geotechnical Engineer, which will establish design criteria for the foundation system and subgrade. It is anticipated that foundation elements will consist of spread footings on improved soil (GeoPiers or equal) or cased drilled shafts (caissons). See the preliminary geotechnical investigation in Appendix B.

b. Slab on Grade: Slab on grade is to be concrete, not asphalt. Control and construction joints in slab on grade shall be sealed with joint sealant and be spaced to minimize shrinkage cracking (approximately 10’-15’ on center). Fiber reinforcement may be considered in lieu of welded wire fabric upon review of site mockup.

c. Superstructure:

   i) Precast prestressed concrete system: The system will be comprised of precast prestressed concrete double tees, columns, beams, spandrels, ramp walls (with openings), shear walls (with openings), stair walls, elevator walls, trash room walls, and
stairs. Top surface of precast spandrels to be sloped back into the deck to minimize staining of the exterior face from rainwater.

d. Medium broom finish or medium swirl finish required on all vehicular driving surfaces.

e. Vehicular barriers: Provide vehicular barriers along the perimeter and along ramp sides.

   i) Cast-in-place or precast barrier walls are preferred, however, in limited applications, cable barriers may be used. Cable barrier shall be 7-wire galvanized prestressing strand intended for use as a vehicular barrier. Where cable passes through a column, the hole should be sealed with caulk to prevent water intrusion at the anchor.

f. Sleeves for fire protection, plumbing, and other miscellaneous items shall be coordinated with those trades.

4.3 DURABILITY

The parking structure shall be designed for a 50-year design life in accordance with the most recent edition of the American Concrete Institute “Guide for the Design of Durable Parking Structures” (ACI 362). Regardless of the structural system utilized, the concrete structure for the parking structure shall meet or exceed the specified characteristics for structures located in durability Zone I. Specific criteria are as detailed below.

a. Concrete mix designs:

   ii) Use 6% +/- 1.5% air entrainment for superstructure members.

   iii) Use chert-free aggregate where possible.

   iv) Silica fume and/or calcium nitrite may be used to densify the concrete and to inhibit corrosion, however the designer is encouraged to review local capabilities.

   v) Use of a plant or site-added superplasticizer for workability is allowed.

   vi) Use fly-ash (minimum = 10%, maximum = 25%) as a supplementary cementitious material for added durability and sustainability.

   vii) Corrosion inhibitor admixture, if used to reduce cover or improve design service life, shall be added at the manufacturer’s recommended rate but not less than 2.0 gallons per cubic yard.

b. Cast-in-Place Concrete: Additional recommendations per ACI 362 are noted for cast-in-place post-tensioned concrete in Zone 1.

   i. Minimum concrete compressive design strength, \( f'c = 3,500 \text{psi} \).

   ii. Use encapsulated tendons is preferred but not required.
iii. Minimum average prestressing: Primary members = 175 psi; Shrinkage and temperate = 100 psi.

iv. Cover: Typical = 1.5"; Slab bottom = ¾”.

c. Precast Concrete: Additional recommendations per ACI 362 are noted for precast/prestressed concrete.

i. Minimum concrete compressive design strength, f’c = 5,000psi.

ii. Cover: Typical = 1.5"; Beams = 1.25”

iii. Hot-dipped galvanized connections for typical connections and/or stainless steel for flange-to-flange connections shall be utilized. Galvanized and stainless-steel components shall not be used in the same connection.

iv. Following erection, Precaster shall epoxy inject or rout and seal all cracks in the precast members in coordination with and approval by the structural engineer of record.

v. Sleeves, connections, and lifting points shall be detailed and patched/protected to prevent deterioration.

d. Refer to ASU Project Guidelines 03 31 00 Structural Concrete, 03 45 00 Architectural Precast Concrete and 05 50 00 Metal Fabrications.

4.4 VERTICAL CLEARANCES

The parking structure must be designed with 8’-2” clearance where ADA van-accessible spaces and van-accessible vehicular access routes are located. All other areas shall have a minimum vertical clearance of 7’-0". Designer should consider additional construction tolerances when setting floor-to-floor heights.

4.5 VOLUMETRIC

Designer shall demonstrate that volumetric change effects have been accounted for in the design of this exposed structure, and provide closure pour strips or expansion joints accordingly. Volumetric effects include, but are not limited to, seismic displacements, wind displacements, thermal movements, shrinkage, elastic shortening, and creep. One expansion joint is anticipated for the indicated configuration.

5 ARCHITECTURAL

5.1 FAÇADE

a. The façade should replicate the design as indicated by the Conceptual Drawings (provided in Appendix A) with the following materials:

i. Metal panels and woven wire fabric on a minimum of 30% of the exposed façade.

ii. Lower level area ways to accommodate an S-2 open parking structure on all levels if a basement if provided.
b. Provide floor to floor heights of 11'-6" from Levels 1-2 and 10'-6" on all other levels. If future ground level retail is planned for a portion of Level 1, the floor to floor height should be increased to 14'-0" minimum.

c. Suicide prevention elements (taller roof parapets, signage, softening of the building hardscape with awnings and landscape, etc.) should be incorporated into the design. Designers are encouraged to suggest other ideas aid in suicide prevention.

5.2 FUTURE EXPANSION

a. The parking structure should be designed to be vertically or horizontally expanded to 2,200 cars including the potential future conversion of approximately 13,000 SF of parking area on Level 1 to shell occupied space. The following elements shall be considered in the initial design to accommodate the future expansion.

   i. Building Type classification.

   ii. Future expansion of stair and elevator cores.

   iii. Stair egress widths for life safety.

   iv. Waterproofing over future shell space.

   v. Vibration isolation of parking structure are over further shell space.

   vi. Inclusion of storefront and canopy structures.

   vii. Fire protection system.

   viii. Connection for a future skybridge to ISTB7 attached to the Southeast stair/elevator core at Level 3 of the parking structure.

   ix. Refer to ASU Project Guidelines 08 44 00 Curtain Walls.

5.3 ELEVATORS

a. Provide a minimum of 3 elevators at in the Phase 1 parking structure. Future elevator cores shall be provided for future expansion. Designer should consider additional queuing analysis to determine whether more than 3 elevators is necessary.

b. Use a minimum of 3,500 lbs. cabs with side opening doors. Glass backed elevators are not desired.

c. Use rigidized stainless-steel walls to minimize vandalism.

d. Heat and cool all elevator machine rooms and hoistways if machine room-less traction elevators are used.

e. Trailing cables should have capabilities of telephone, security, audio and CCTV.
f. Elevator preference is a machine room-less traction elevator. If this elevator type is used, accommodations for hoistway cooling will be required.

g. Flooring at elevator landings should be coated with durable coating for ease of cleaning, maintenance, and aesthetics.

h. Use vandal proof elevator buttons.

i. Elevator manufacturer shall provide on-site training and maintenance overview for ASU staff.

j. Provide elevator pit ladders.

k. Elevator vestibules can be open but the door thresholds should be protected from the weather including blowing rain. An open cover/canopy is required at the roof.

l. Refer to ASU Project Guidelines 14 20 00 Elevators and 14 27 00 Passenger Cabs – Interior.

5.4 STAIRS

a. All stairs and landings shall be constructed of concrete and have a non-slip floor finish. No steel stringers or steel pans are allowed.

b. Stair treads shall provide a high traction surface and provide visual contrast (light-on-dark or dark-on-light) on tread nosings.

c. Where paint is provided on the interior walls and/or ceiling, paint or stains shall be easy to clean and maintain. No flat finishes are acceptable. Floor colors and paint codes will be provided by ASU.

5.5 SIGNAGE AND WAYFINDING

a. An identification system, for both vehicles and pedestrians, consisting of floor graphics, column and wall graphics and signage, shall be incorporated into the design of the parking structure. Background color shall be consistent and coordinated throughout. The final designs and materials must be approved by ASU prior to installation. Signage should be provided per ASU Design Standards.

b. Plate metal signs shall be aluminum with minimum sheet thickness of 0.125 inches.

c. Plate metal signs shall be securely anchored to the structure with Hilti Metal HIT anchors or similar vandal proof anchors. Adhesives are not acceptable as the sole source of connection.

i. If using precast concrete, do not mount directly to precast double tee stems.

d. Headache/clearance bars (6” minimum diameter) shall be installed at each entry/exit point over all lanes, both inbound and outbound, indicating the vertical clearance beyond. Additional clearance bars shall be provided within the structure in advance of locations where internal clearances change.

e. Interior parking areas (including columns) to be painted/stained white.
f. Refer to ASU Project Guidelines 10 14 00 Signage and Wayfinding.

5.6 BICYCLES

a. A bicycle enclosure shall be provided per ASU Design Guidelines.

b. Where bicycle parking is not clearly visible to approaching cyclists, signs shall be posted to direct cyclist to the parking area.

c. Bicycle parking shall not impede pedestrian or vehicle movement or circulation.

d. Each bicycle space shall accommodate a bicycle at least 6 feet in length and 2 feet wide or be in an ASU approved bike locker or bike space.

e. A minimum aisle width of 4 feet should be provided for bicycles to enter and leave the facility to access the public way.

5.7 RAILINGS

a. Provide galvanized or powder coated stair railings, wall railings, and ramp railings. Refer to ASU Project Guidelines 05 50 00 Metal Fabrications.

5.8 WATERPROOFING

a. Traffic bearing membranes shall be applied over occupied spaces or any rooms such as the mechanical/electrical room. This area shall receive a traffic coating that extends 2’ minimum beyond the limits of the room below.

b. Seal control joints, construction joints and coves with a two-component polyurethane sealant rated for traffic.

c. Membrane roofing over elevators and stair towers.

d. Provide a split slab waterproofing system over future occupied space (shell retail) area. Installation of the waterproofing should be by a manufacturer’s certified installer.

e. Water repellent sealer: Install a low VOC, 100% solids penetrating concrete silane sealer to the roof level directly exposed to the exterior.

f. Provide below grade waterproofing behind walls and at the elevator pit(s), including waterstops at construction joints. Vapor barriers for the slab on grade shall be per the structural drawings and the geotechnical report.

g. Warranty periods:

i) Traffic coatings shall be covered by a minimum 5+5 year joint and several warranty (manufacturer and installation contractor).

ii) Sealers, sealants, and expansion joints shall be covered by a minimum five year joint and several warranty (manufacturer and installation contractor).
iii) Roofing and split slab waterproofing system shall be covered by a minimum twenty year joint and several warranty (manufacturer and installation contractor). Refer to ASU Project Guidelines 07 50 00 Roofing Systems.

n. Refer to ASU Project Guidelines 07 13 00 Sheet Waterproofing and 07 50 00 Roofing Systems and 07 90 00 Sealants.

5.9 ROOMS

a. There should be one (1) electrical room within the parking structure.

b. A minimum 750 SF office space (with two offices one of which shall have a pass-through window) and storage area for parking management use shall be provided in the parking structure with a single employee restroom and custodial closet.

c. A minimum of two (2) IT/IDF rooms shall be provided on every floor.

d. Two card-access restrooms near the bike racks/enclosure.

e. Storage rooms shall be provided in the areas under the ramps.

f. Space for future photovoltaic equipment room in or near the electrical room.

g. Refer to ASU Project Guidelines 08 Openings, 09 Finishes, 10 Specialties and 12 Furnishings.

5.10 DOORS AND HARDWARE

a. Hollow metal doors and frames with commercial grade hardware for all storage/mechanical,IDF rooms within the parking structure.

b. All doors shall have card reader access.

c. Refer to ASU Project Guidelines 08 11 00 Hollow Metal Doors and Frames, 08 11 16 Aluminum Doors and Frames, 08 70 00 Finish Hardware / Electronic Card System and 08 80 00 Glass and Glazing.

5.11 EQUIPMENT

a. Space shall be allocated for trash and recycling cans at each stair and elevator lobby on every level. The placement of trash and recycling cans should not encroach on the required egress widths or access to the stairs/elevators.

b. Fire extinguishers at each elevator bank and throughout garage to meet code spacing requirements.

c. Provide concrete-filled galvanized steel pipe bollards to protect equipment and establish safe areas for pedestrians.

d. Refer to ASU Project Guidelines 10 44 00 Fire Extinguishers.
6 ELECTRICAL

6.1 LIGHTING

a. LED fixtures should be used. Fixtures shall be Philips Gardo SVPG 168L. Refer to ASU Project Guidelines 26 50 00 Lighting.

b. Fixtures should be installed in a two row per bay configuration, unless photometric studies indicate that alternate configurations can meet the minimum and maximum lighting requirements.

c. Provide a point-by-point foot candle (fc) photometric analysis to illustrate the design intensity levels at each level of the parking structure.

d. Minimum, maximum, and uniformity levels of illumination shall be the greater of requirements from the Illuminating Engineering Society of North America (IESNA) RP-20 latest edition, or the following:

<table>
<thead>
<tr>
<th>Area</th>
<th>Minimum Lighting (fc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average maintained in driving aisles &amp; parking spaces (except the top level)</td>
<td>5</td>
</tr>
<tr>
<td>Minimum in driving aisles &amp; parking spaces</td>
<td>2</td>
</tr>
<tr>
<td>Average maintained at ingress/egress areas (daytime)</td>
<td>40</td>
</tr>
<tr>
<td>Minimum maintained at ingress/egress areas (daytime)</td>
<td>14</td>
</tr>
<tr>
<td>Maximum at ingress/egress (daytime)</td>
<td>100</td>
</tr>
<tr>
<td>Average maintained at ingress/egress (after dark)</td>
<td>20</td>
</tr>
<tr>
<td>Minimum at ingress/egress (after dark)</td>
<td>7</td>
</tr>
<tr>
<td>Maximum at ingress/egress (after dark)</td>
<td>50</td>
</tr>
<tr>
<td>Average maintained at entrance, exits, stairs, and elevator lobbies</td>
<td>20</td>
</tr>
<tr>
<td>Average maintained in occupied spaces</td>
<td>10</td>
</tr>
</tbody>
</table>

6.2 POWER DISTRIBUTION

a. Provide electrical convenience outlets on each floor spaced approximately 200’ apart that are secured with a cover and lock.

b. For durability and maintenance reasons, exposed conduits are preferred. If, however, ASU or the Designer overseeing the project wishes to use an encased conduit system then plastic conduit with a grounding wire should be considered.

c. Backup power should be provided to the following elements:
   i. Elevators
   ii. Emergency lighting
iii. CCTV

d. A lightning protection system shall be provided.
e. Refer to ASU Project Guidelines Division 26 Electrical.

## 7 PLUMBING

### 7.1 DRAINAGE

a. All floor surfaces shall be positively sloped for drainage by a minimum of 1 ¼% (preferably closer to 2%) in any direction at any point. Care must be taken in a precast system to consider the residual camber of double-tees. Furthermore, warping stresses of the members should be minimized. Proceeding with the pouring of CIP concrete or the fabrication of precast concrete members is acceptance of the design as being adequate to provide positive drainage of water after industry construction and fabrication tolerances are considered. Contractor shall be responsible to see that all water positively drains to the drainage system. Care must be also taken in areas of accessible parking spaces and aisles where the maximum slope is 2%.

b. Drainage shall be towards the interior of the parking structure so that no vertical risers are visible on the perimeter façade.

c. Areas with cast-in washes, or cast-in-place toppings should also be accounted for when draining to floor drains. Completed system must allow water to drain to the drains, minimizing any standing water on the floors. Washes are preferred to curbs in all applications.

d. Scupper openings shall be provided at the base of the shear walls, where applicable, at each level to allow drainage through the wall to the adjacent area drain.

e. Drain heads should be large with large net free areas. Use sediment bucket where possible. Minimum 6” deck drain pipes with no 90-degree connections and no pipes less than 6” diameter.

f. Provide an easily accessible clean-out on the parking structure for the drainage system.

g. Provide lockable deck drain covers to prevent vandalism.

h. Refer to ASU Project Guidelines 22 13 00 Facility Sewerage.

### 7.2 PIPING

a. Horizontal plumbing lines should not decrease the minimum head room design of the facility.

b. All vertical utility lines, including risers, shall be protected by a steel pipe guard designed to resist bumper impact.

c. All pipe insulation should be protected with aluminum jacket to prevent damage from birds.

d. Refer to ASU Project Guidelines 22 10 00 Piping Standards, 22 30 00 Plumbing Systems and 22 13 00 Facility Sewerage.
7.3 HOSE BIBS

    a. Provide 1 ½” diameter minimum wash down hose bibs on each floor. System shall be designed to be manually drained down prior to each winter.

7.4 PIPE PROTECTION

    a. Provide galvanized bumper guards at all plumbing leaders, downspouts and exposed electrical conduit. Guards should allow maintenance of the elements but provide strike zone protection from 9” to 30” above finished floor.

7.5 CODE REVIEW

    a. Review local code for separation of roof water from typical level water collection.

    b. Review code for need for oil separators. Where required, install an alarm to alert the parking management team when cleaning is required.

8 FIRE PROTECTION

    a. It is preferred to maintain an openly ventilated parking structure to use a dry standpipe system and minimize the need for an automatic fire sprinkler system or alarm system.

    b. Locate a siamese connection near the vehicular entrance and fire hydrant in coordination with local fire department reviews.

    c. Provide for fire or smoke detectors at elevator lobbies per applicable code.

    d. Interior fire department connections shall not be obstructed by a parked vehicle. A minimum 3'-0” access aisle shall be provided to these connection points.

    e. Hose connections and valves shall not protrude in such a way as to present a safety hazard to pedestrians.

    f. Refer to ASU Project Guidelines 21 10 00 Fire Suppression.

9 MECHANICAL

    a. It is preferred to maintain an openly ventilated parking structure to minimize the need for mechanical ventilation.

    b. Provide packaged terminal HVAC equipment for specialized spaces within the proposed parking structure that require cooling, electric heaters for spaces that require heating only, and an exhaust fan and louver systems for ventilation as required.

    c. Refer to ASU Project Guidelines 23 05 00 HVAC.
10 SAFETY AND SECURITY

10.1 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN (CPTED)

Design should consider passive security systems including, but not limited to, the following designs/components:

a. Openings shall be incorporated into any enclosures (other than electrical, IDF and storage rooms) or walls and stair towers to allow clear visibility not only from the inside out, but from the outside in.

b. Provide openness to allow maximum natural light.

c. Minimize interior walls or corners which might be perceived as areas where people can lurk, and which will also minimize sight line obstructions for drivers.
   i) Shear walls - Minimize length of shear walls at end turning bays to minimize the sight line obstructions. In addition, provide openings (as large as possible) in the shear walls.

d. Use a well-lit and well-distributed lighting system (see recommended illumination as stated in the lighting recommendations section).

10.2 BLUE PHONES / CCTV

a. Security phones (call for assistance or blue light) are to be located adjacent to each of the stair towers on each level. Call for assistance stations shall have blue or other acceptable lights. Each station, when activated, should allow for two-way communication. The system shall ring the local officials as coordinated with the Owner. The system should have a one-year warranty for full maintenance and service per ASU Design Standards.

b. Closed circuit television (CCTV) cameras should monitor each vehicular entry/exit location, each pedestrian entry/exit location, parking office and each stair/elevator lobby per ASU Camera Standards.

10.3 DATA / BUILDING INFORMATION SYSTEMS

a. Fire alarm, CCTV, emergency intercoms, and PV monitoring should be integrated into the campus Facility Management System.

b. Refer to ASU Project Guidelines 25 51 00 Facility Management System and 28 30 00 Fire Alarm System Codes and Standards.

11 SUSTAINABILITY

ASU will pursue Parksmart Certification through the Green Business Certification, Inc. (GBCI). The Designer should incorporate sustainable elements into the design and construction of the building. Some sustainability elements are noted below:
a. Energy efficient lighting fixtures which should be on a single photocell sensor contact per floor, or other control mechanisms can be considered. These controls either dim the lights or switch off the lights during periods of low usage in the parking structure or when ambient light is enough on the perimeter to allow fixtures to dim or shut off by floor section.

b. Low VOC: Traffic coatings, sealers, and other materials shall contain less than 400 g/L of VOCs.

c. Incorporate fly ash (a waste by-product) into the concrete mix designs.

d. Provide parking spaces reserved for low emission, hybrid, and electric vehicles.

e. Accommodation for future installation of rooftop photovoltaic cells similar to existing campus parking structures.

f. Native or drought-tolerant plants.
NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND HAS BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY, TOPOGRAPHY, UTILITIES, CONTACT WITH THE CITY, ETC.

Arizona State University
Tempe Novus Parking Structure

PHASE 1
SITE PLAN
1,250 SPACES

SHARED ACCESS DRIVE

AVAILABLE BUILDING FOOTPRINT

POTENTIAL BASEMENT AREA WAY
PHASE 1
EXISTING AERIAL PLAN
NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND HAS BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY, TOPOGRAPHY, UTILITIES, CONTACT WITH THE CITY, ETC.
Arizona State University
Tempe Novus Parking Structure

PHASE 1
LANDSCAPE PLAN
NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND HAS BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY, TOPOGRAPHY, UTILITIES, CONTACT WITH THE CITY, ETC.

PHASES 1 AND 2
CONCEPTUAL RENDERINGS
APPENDIX B
REPORT ON PRELIMINARY
GEOTECHNICAL INVESTIGATION

DESIGNATION: Tempe Parking Structure

LOCATION: NWC University Drive & G Street
Tempe, Arizona

CLIENT: ASU - CPMG

PROJECT NO: 180516SA

DRAFT DATE: May 2, 2018
# TABLE OF CONTENTS

1.0 INTRODUCTION ................................................................................................................. 1

2.0 GENERAL SITE AND SOIL CONDITIONS .............................................................................. 1

   2.1 Site Conditions ................................................................................................................ 1

   2.2 Geological Conditions ..................................................................................................... 2

   2.3 Seismic Design Parameters ............................................................................................ 3

   2.4 General Subsurface Conditions ....................................................................................... 3

3.0 ANALYSIS AND RECOMMENDATIONS .............................................................................. 4

   3.1 Analysis .......................................................................................................................... 4

   3.2 Site Preparation .............................................................................................................. 7

   3.3 Excavation and Temporary Cut Slopes ........................................................................... 8

   3.4 Shoring ........................................................................................................................... 9

   3.5 Foundation Design ......................................................................................................... 10

   3.6 Lateral Pressures ........................................................................................................... 13

   3.7 Fill and Backfill ............................................................................................................. 13

   3.8 Utilities Installation ......................................................................................................... 15

   3.9 Slabs-on-Grade ............................................................................................................. 15

   3.10 Asphalt & Concrete Pavement ..................................................................................... 15

4.0 GENERAL ............................................................................................................................ 17

APPENDIX – Current Field and Laboratory Data
1.0 INTRODUCTION

This report presents the results of a preliminary subsoil investigation carried out at the site of the proposed Tempe Parking Structure to be constructed at the northwest corner of University Drive and G Street in Tempe, Arizona.

We understand that future design and construction will consist of a parking structure. The structure will be about 6 stories above grade with one level below grade. The first phase, of three, will be for approximately 940± spaces. This report is intended to provide preliminary data for all three phases. Maximum column structural loads will be moderate to heavy and no special considerations regarding settlement tolerances known at this time. Adjacent areas will be landscaped or paved to support moderate volumes of auto traffic and service truck traffic. The need for and methods used to collect and dispose of storm water are not known at this time. If underground tanks are used, it may have an impact on the foundation design.

This project will be issued as a Design-Build project. This report is intended to be preliminary for inclusion in the bridging documents for the potential final design-build team. That team should determine the extent of any future final investigation needed for the selected design concept.

2.0 GENERAL SITE AND SOIL CONDITIONS

2.1 Site Conditions

The site is currently bounded on the north and east by Alpha Drive, on the south by University Drive, on the southwest by light rail tracks followed by Veterans Way and on the northwest by an adjacent vacant lot followed by 6th Street. The majority of the site is currently occupied with undocumented granular fill and partially occupied with a construction yard on the east side. The site was originally partially agricultural land with small structures until the early 1960’s when residential type buildings with pools were constructed as part of ASU student housing, aka “fraternity row”. The site remained residential until around the year 2010 when the majority of the buildings started being demolished and cleared. In 2016 there appears to be large stockpiles of material on site. Please refer to the following historical aerial photos:
2.2 Geological Conditions

The site is located outside known areas that have undergone considerable subsidence due to groundwater removal. Areas of subsidence are known to produce earth fissuring, which has affected areas within several miles of the site. Subsidence is a basin wide phenomenon that would result in differential elevation changes over long distances, which would not affect the type of buildings proposed for this site. No evidence of earth fissures was observed on the site. Fissure gullies form over subsurface irregularities such as bedrock highs, which cause tensional stresses and differential subsidence. Where such anomalies are not present, subsidence tends to be uniform over a wide area, this having minimal effect on surficial structures. The closest known earth fissures are located in the Chandler Heights area and in East Mesa, many miles from this site. Based on local experience, subsidence and earth fissures historically have not been a problem in this area.
2.3 Seismic Design Parameters

The project area is located in a seismic zone that is considered to have low historical seismicity. The seismicity of the Phoenix area has had only three magnitude 3.0 events in over 100 years.

Although borings were not advanced to 100 feet, based on the nature of the subsoils encountered in the borings and geology in the area, Site Class Definition, Class C may be used for design of the structures supported on drilled shafts. In addition, the following seismic parameters may be used for design (based on 2008 USGS maps adopted by 2012/15 IBC):

<table>
<thead>
<tr>
<th>Table 2.3.1 Seismic Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCE superscript 1 spectral response acceleration for 0.2 second period, S\textsubscript{S}: 0.178g</td>
</tr>
<tr>
<td>MCE superscript 1 spectral response acceleration for 1.0 second period, S\textsubscript{1}: 0.058g</td>
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<tr>
<td>Site coefficient, F\textsubscript{a}: 1.2</td>
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<tr>
<td>Site coefficient, F\textsubscript{v}: 1.7</td>
</tr>
<tr>
<td>MCE superscript 1 spectral response acceleration adjusted for site class, S\textsubscript{MS}: 0.213g</td>
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<tr>
<td>MCE superscript 1 spectral response acceleration adjusted for site class, S\textsubscript{M1}: 0.099g</td>
</tr>
<tr>
<td>5% Damped spectral response acceleration, S\textsubscript{DS}: 0.142g</td>
</tr>
<tr>
<td>5% Damped spectral response acceleration, S\textsubscript{D1}: 0.066g</td>
</tr>
</tbody>
</table>

Note: MCE = maximum considered earthquake

2.4 General Subsurface Conditions

The subsoil conditions at the site consist primarily of silty gravel, clayey gravel, clayey sand and sandy silty clay to a depth of 5 to 9 feet underlain by silty sand, well graded sand, sandy silty clay, poorly graded gravel and silty gravel to the termination depths of the borings at 8.0 to 50.1 feet below existing grade. It should be noted that fill material was encountered in each of the borings ranging from 0.5 to 9 feet in depth. Auger refusal on cobbles was encountered in borings B-1 to B-3. Boring B-4 was advanced to 50 feet using a Tubex downhole hammer system and encountered weathered bedrock at a depth of 48 feet below existing grade. Standard Penetration Resistance Test (SPT) values range from 5 to 50+ blows per foot. Loose/soft soils were encountered in borings B-3 to a depth of 5 feet and B-4 to a depth of 10 feet below existing grades. It is likely that loose soils also exists to similar depths below boring B-1 & B-2, however to the auger refusal on the cobble laden fill this was not confirmed. Based on visual and tactile observation, the soils were in a ‘dry to moist’ state at the time of investigation.
Laboratory testing indicates in-situ dry densities of the soils ranged from 88 to 93pcf and water contents from 8.3 to 10.0 percent at the time of investigation. Liquid limits range from non-plastic to 28 percent with plasticity indices at non-plastic to 5 percent. The upper 5 feet of clayey soils exhibit volume increase due to wetting of 2.1 percent when compacted to moisture and density levels normally expected during construction. ‘Undisturbed’ samples in the upper soils displayed significant (6.5%) compression under incremental loading and minor (2.5%) additional compression due to inundation under a maximum confining load of 6,400 psf. ‘Undisturbed’ samples in the soils at a depth of 10 feet displayed significant (8.0%) compression under incremental loading and minor (2.5%) additional compression due to inundation under a maximum confining load of 12,800 psf. Direct shear tests on undisturbed samples of the lower soils at a depth of 15 feet indicated cohesion of 706 psf and an angle of friction of 37 degrees.

3.0 ANALYSIS AND RECOMMENDATIONS

3.1 Analysis

It is assumed that the main parking structure with one level below grade would have a finished floor elevation of approximately 10 feet below existing grade. Based on the soils borings completed to date, this will leave approximately 8 feet of medium dense, compressible material which is not suitable for bearing due to the expected moderate to heavy concentrated loads. Therefore it is primarily recommended to support the proposed structure on drilled shafts (caissons). In lieu of using drilled shafts, consideration may be given deepening the lower level to 1½ - 2 levels below grade in order to support the structure on shallow spread footing or mat foundation bearing on the dense sand gravel cobble (SGC) layer of soils at approximately 20 feet below existing grade. Shallow spread footing can also be over-excavated the planned footing width to contact the SGC layer and backfilled with slurry. Another option is to use spread footings bearing on “stone columns” such as Rammed Aggregate Piers®/ GeoPiers™/Vibro Piers to transfer loads through the loose soil layer.

For any portion of the structure that will be partially supported beyond the perimeter of the basement walls, drilled shafts or other deep ground improvement options combined with structural slabs spanning the backfill are recommended to transfer loads to the same bearing media.

Placement of footings bearing in wall backfill material is not recommended. Any footings located in the backfill zone next to the basement wall should be deepened below the ‘line of influence’ to avoid surcharge on the wall. Footings for any surface structures should be situated such that they are not located within any backfill zone and that a 45-degree plane below an upper foundation does not intersect the walls of an adjacent structure. This will prevent the imposition of foundation surcharge loads on the walls. If this is not practical, the design of the wall should consider the additional lateral surcharge and transfer of load
over the wall backfill zone. In addition, only lightly loaded foundations (single story structures) should be considered for this (not moderate to heavily loaded foundations).

As indicated, the upper soils contain fill material to a depths as great as 9 feet underlain by the relatively inconsistent, soft/loose, fine grained soils to depths of 18 to 20 feet. In addition laboratory testing indicates the soils are susceptible to moisture induced collapse. This could result in excessive differential settlement resulting in cracking problems. Accordingly, for shallow spread footing options for any at grade lighter structures, recommendations are made to over-excavate and re-compact the bearing soils to increase density and reduce the potential for collapse. Attention must be paid to provide proper drainage to limit the potential for water infiltration of deeper soils.

For standard foundations to perform as expected, attention must be paid to provide proper drainage to limit the potential for water infiltration of deeper soils. It is assumed that the landscape plan will use mostly low water use or "green" desert type plants (xeriscape). It is preferred to keep irrigated plants at least 5 feet away from structures with irrigation schedules set and maintained to run intermittently. Unpaved planter areas should be sloped at least 5 percent for a distance of at least 10 feet away from the building. While this is the ideal condition, we recognize that this is not always possible in order to meet ADA slope requirements for the adjacent sidewalks. The slope may be reduced to 2 percent provide extra care is taken to ensure sidewalks and other hardscape features do not create a “dam” that prevents positive drainage away from the buildings that creates a "pond" adjacent to the building. Sidewalks should not be placed (or planters graded) that could create a "pond" adjacent to the building. Roof drainage should also be directed away from the building in paved scuppers. Pre-cast loose splash blocks should not be used as they can be dislodged and/or eroded. Roof drains should not be allowed to discharge into planters adjacent to the structure. It is preferred that they be directed to discharge to pavement (per photo example), retention basins or discharge points located at least 10 feet away from the building.

It is reiterated that shallow spread footings are recommended for light ‘at-grade’ structures, if any are planned, and outside the basement level zone of influence, since this is the most economical system available. However, this shallow system relies on the dry strength of the unsaturated native soils. A limited depth of re-compaction is recommended to increase density of the near surface soils that are more likely to encounter seasonal moisture changes. The deeper native soils are moisture sensitive and could experience differential settlement if subjected to significant surface water infiltration. Recognizing the need to minimize significant water penetration adjacent to the building perimeter that could detrimentally impact the building foundation, the following additional recommendations are made to protect foundations:
1. Take extra precaution to backfill and compact native soil fill to 95 percent in all exterior wall locations.
2. Avoid utility trenches passing through retention basins leading to the building. If unavoidable, backfill the trench with MAG Section 728 ½-sack CLSM to cut off preferred drainage paths.
3. Avoid placing retention basins next to building foundations. A distance of at least 10 feet should be maintained between structures and the location of the basin maximum fill level.
4. Create and maintain positive drainage away from the exterior wall for a minimum of 10 feet.
5. Avoid sidewalks, curbs or other elements that create a dam that could cause water to pond within 5 feet of the perimeter wall.
6. Include no irrigated landscape materials in the first 3 feet next to the building.
7. Between 3 feet and 5 feet, include only landscape materials that can be irrigated with a maximum of 1 gallon per hour emitter heads. Set and maintain irrigation controllers to prevent 24/7 flows.
8. Any landscape materials requiring greater than 1 gallon per hour irrigation, including turf, shall be at least 5 feet from the outside face of the building.
9. All irrigation feeder lines, other than those that supply individual emitters, shall not be placed closer than 5 feet to the building.

Excavation operations should be relatively straightforward in the upper soils using conventional equipment although the presence of cobbles at deeper depths may require the use of heavier equipment. It should be noted that the fact that a boring was advanced to a particular depth should not lead to the assumption that it is necessarily excavatable by conventional means. Very dense SGC may require more aggressive removal techniques. Secondly, there may be some stability issues with attempting to advance excavations into the SGC zone and with “Running Sand”. **Likewise for the caisson construction will be difficult in the cobble laden soils and “Running Sand” and will likely require casing and/or slurry to maintain open shafts or expect large over-runs on concrete volumes.**

Groundwater is not expected to be a factor in the design or construction of foundations and underground utilities. The following recommendations regarding below-grade, basement wall water-proofing and drainage are based on the assumption that water infiltration from the surface will likely be relatively low-volume, short-term and should dissipate quickly and that the drainage from the podium deck will be directed to a piped drainage system and not be allowed to discharge into the wall water-proofing system. The lower level foundations will bear on the dense granular native soil. To handle low-volume nuisance surface water, it is recommended to include vertical strip or sheet geo-composite drains (i.e. Cetco Aquadrain, AWD Amerdrain) to prevent any hydrostatic build-up that could compromise the wall water-proofing system. Where drainage swales and/or retention basins are planned within 15 feet of basement walls, sheet geo-composite drains and waterproofing is recommended. While it is expected that the soils at foundation elevation to be relatively permeable, it is recommended to include a detail to bring wall drainage into the basement level above.
the footings directed to a sump pump system. This will reduce the potential for wall drainage to wet the bearing soils causing a loss of support and differential settlement.

For exterior slabs on grade, frequent jointing is recommended to control cracking and reduce tripping hazards should differential movement occur. It is also recommended to pin the landing slab to the building floor/stem wall. This will reduce the potential for the exterior slab lifting and blocking the operation of out-swinging doors. Pinning typically consists of 24 inch long No. 4 reinforcing steel dowels placed at 12-inch centers.

3.2 Site Preparation

The site should be stripped of all vegetation, debris, rubble undocumented fills and obviously loose surface soils. Excavation for the lower level should remove all of the undocumented fills. Outside of the basement areas, it is recommended to over-excavate the entire site at least 18 inches below existing grade to aid in locating shallow buried hazards. Old foundation elements (if any) should be removed in their entirety along with soil disturbed by this activity. All resulting excavations should be widened as necessary to allow access for compaction equipment.

For the at grade shallow footing option (if any), subsoils should be further over-excavated at least 2 feet below proposed footing bottom elevation, or existing grade, whichever is deeper, extending at least 5 feet beyond the footing edges within all footing areas. It may be more feasible to just over-excavate the entire building pad if the building footprint is relatively small.

A representative of the geotechnical engineer should examine the subgrade once sub-excavation is complete and prior to backfilling to ensure removal of deleterious materials and confirm proper bearing media. Fill placement and quality should be as defined in the "Fill and Backfill" section of this report.

If any utility is located within 10 feet of any proposed foundation, relocation and/or abandonment of the utility should be provided. They should either be removed and replaced with engineered fill or abandoned in-place. In the case of manholes and pipelines, it may be possible to abandon them in-place. The tops of manholes should be removed and filled with a weak (>500 psi) cementitious grout. Pipelines larger than 6 inches should be capped and filled with grout. Sub-excavation of foundations, curb-and-gutter and any underground utilities should be provided to ensure complete removal of all structures, deleterious materials and disturbed soils.
Prior to placing structural fill below footing bottom elevation (at grade structures), the exposed grade should be scarified to a depth of 8 inches, moisture-conditioned to optimum (±2 percent) and compacted to at least 95 percent of maximum dry density as determined by ASTM D-698. Pavement areas should be scarified, moisture-conditioned and compacted in a similar manner.

All cut areas and areas that are to receive only slab-on-grade (or sidewalk) fill should be scarified 8 inches, moisture-conditioned to at least optimum to 3 percent above optimum and lightly but uniformly compacted to at least 90 but not more than 95 percent of maximum dry density as determined by ASTM D-698.

3.3 Excavation and Temporary Cut Slopes

Care should be taken during excavation not to endanger nearby existing structures, roadways, utilities, etc. Depending on proximity, existing structures (including utilities) may require shoring, bracing or underpinning to provide structural stability and protect personnel working in the excavation.

All excavations must comply with current governmental regulations including the current OSHA Excavation and Trench Safety Standards. Preliminary indications are that the stiff partially cemented upper fine-grained soils would be classified as Type C. Side slopes for open-cut excavation should be cut back at 1½:1 (horizontal to vertical). The slopes should be protected from erosion due to run-off or long term surcharge at the slope crest. Construction equipment, building materials, excavated soil and vehicular traffic should not be allowed within 10 feet or one-third the slope height, whichever is greater, from the top of slope. All cut slopes should be observed by the Soils Engineer or contractors qualified person during excavation. Adjustments to the recommended slopes may be necessary due to wet zones, loose strata and other conditions not observed in the borings. Localized shoring may also be required. Shotcrete or soil stabilizer on the slope face may be useful in preventing erosion due to run-off and/or drying of the slope or stabilize loose layers. Shotcrete protection is recommended for slopes that will remain open for extended periods of time (more than a week). Provision should be made for drainage (such as weep holes) to mitigate potential build-up of hydrostatic pressure below the shotcrete. If seepage from the slopes is encountered during construction, Speedie should be notified so that these recommendations can be reviewed.
3.4 Shoring

Portions of the excavation cuts will likely encroach on adjacent roadways, adjacent property, and/or buildings. In areas where open-cut excavation is not feasible, consideration must be given to a shoring system. It is suggested to consider using a soldier pile and lagging shoring system for basement walls as this will eliminate a lot of the wall backfill issues discussed below. A standard system made up of steel soldier piles, lagging and tiebacks (or interior bracing), depending on depth and loading is one option. This system typically requires pre-drilling and installing heavy steel shoulder beams spaced on 8 to 10 foot centers and backfilled with lean grout. As the excavation progresses, wood lagging can be installed and tieback anchors installed and tensioned. Cantilever systems may not be possible in the deeper cut areas. For the relatively short periods of time required to install lagging and tiebacks, excavations should stand at vertical. **Sloughing soils may be encountered and require special procedures.** For preliminary design of braced temporary shoring systems, we recommend the following conservative pressure diagram.

\[ H = \text{Depth of Excavation} \]
\[ \gamma = \text{Unit Wet Soil Weight}=110 \text{ pcf} \]

If shoring is required, it may be incorporated into the below-grade wall system whether the wall is cast-in-place or constructed of gunite in top down construction.

Locally, excavations have been braced using the Soil Nail technology. Several firms have experience in the immediate area. This system generally consists of excavating the cut face in increments on the order of 5 feet, installing passive tie back soil nails (anchors) and constructing a reinforced concrete (Shotcrete) face. Consideration may be given to using this system due to the local success, speed of installation and apparent economical cost. Due to the adjacent properties, soil nails may not be acceptable as the soil nails
would need to be drilled into the adjacent property. Specialized contractors should make their own evaluations. Tiebacks installations are expected to encroach on other private/public property. The owner and/or contractor will have to obtain permission as required prior to tieback installation.

Prior to any excavation work commencing, consideration should be given to pre-construction surveys of surrounding buildings, roadways, utilities, etc. It is recommended that each line of shoring be monitored for movement during the construction period, or at least until the at-grade level is in-place. Frequent monitoring of surrounding elements should also be provided during the construction period.

3.5 Foundation Design

If site preparation is carried out as set forth herein, the following bearing capacities can be utilized for design. Mixing foundation elements within a single structure (footings and drilled shafts for example) should be avoided where possible.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Foundation Type</th>
<th>Bearing Medium</th>
<th>Bearing Depth</th>
<th>Allowable Bearing Capacity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor At-Grade Structures</td>
<td>Spread</td>
<td>2 ft. Engineered Fill</td>
<td>1.5 ft.</td>
<td>2,000 psf</td>
<td>1</td>
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<td></td>
<td>Drilled Shafts</td>
<td>Native SGC Soils</td>
<td>20 ft.</td>
<td>See Design Curves</td>
<td>2</td>
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<tr>
<td>Main Structure with 1 level Below Grade</td>
<td>Spread</td>
<td>500 psi slurry</td>
<td>3.0 ft.</td>
<td>10,000 psf</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Aggregate/Stone Piers or GeoPiers™</td>
<td>Native SGC Soils</td>
<td>TBD (~12ft)</td>
<td>~6,000 psf</td>
<td>4</td>
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<tr>
<td></td>
<td>Drilled Shafts</td>
<td>Native SGC Soils</td>
<td>10 ft.</td>
<td>See Attached Design Curves</td>
<td>5</td>
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<tr>
<td>Main Structure with 2 levels Below Grade</td>
<td>Mat</td>
<td>Native SGC Soils</td>
<td>4 ft.</td>
<td>k = 250 pci</td>
<td>6</td>
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<tr>
<td></td>
<td>Spread</td>
<td>Native SGC Soils</td>
<td>4 ft.</td>
<td>10,000 psf</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 3.5.1 Foundation Design
Notes:
1. Spread footings bearing 2 feet below finished grade on at least 2 feet of engineered fill. Assumed the structure is not located within the Main Structure basement wall backfill zone.

2. Drilled shaft capacity charts are found in the Appendix. The tip elevation must terminate in very dense SGC soils at a minimum depth of 20 feet below existing grade. If loose soils are encountered, then shaft depth must be increased to dense bearing soils. Shaft capacity includes skin friction and end bearing.

3. Depth refers to bottom of spread footing below lower level floor elevation. Footings should be over-excavated to remove unsuitable soils and backfilled back to bottom of footing with cementitious slurry with 500 psi compressive strength CLSM per MAG Standard Specification Section 721 or structural concrete.

4. Spread footings supported on highly compacted “stone columns” extended down to the very dense native soils. These proprietary foundation systems are typically designed by the specialty contractor. Contact Hayward Baker or Western Ground Improvement for details and performance criteria.

5. Drilled shaft capacity charts are found in the Appendix. The tip elevation must terminate in very dense SGC soils at a minimum depth of 10 feet below lower level finished grade. If loose soils are encountered, then shaft depth must be increased to dense bearing soils. Shaft capacity includes skin friction and end bearing.

6. Depth refers to bottom of concrete mat foundation below lower level floor elevation bearing on very dense native SGC soils. A modulus of subgrade reaction k of 250 psi may be used for design. A maximum contact pressure of 10 ksf is assumed at the bottom of the mat.

7. Depth refers to the bottom of spread footings below lowest level floor elevation bearing on very dense native SGC. In any isolated footings not exposing suitable bearing soils, the footing should be over-excavated to remove unsuitable soils and backfilled back to bottom of footing with 500 psi compressive strength CLSM per MAG Standard Specification Section 721 or structural concrete.

These bearing capacities refer to the total of all loads, dead and live, and are net pressures. They may be increased one-third for wind, seismic or other loads of short duration. These values may be increased by one-third for wind, seismic, or other loads of short duration.

Continuous masonry wall footings and isolated rectangular footings should be designed with minimum widths of 16 and 24 inches respectively, regardless of the resultant bearing pressure.

Estimated settlements of **basement level spread footings** under maximum design loads are on the order of ¾ to 1-inch, virtually all of which will occur during construction. Rammed aggregate or vibro-replacement stone improved soils settlement is expected to be similar depending on load, diameter and length (typically >30% reduction in comparison to untreated soils). Additional localized settlements could occur if native supporting soils were to experience a significant increase in moisture content. Positive drainage away from structures, and controlled routing of roof runoff **must** be provided to prevent ponding adjacent to perimeter walls. Planters requiring heavy watering should be considered with caution. Care should be taken
in design and construction to insure that domestic and interior storm drain water is contained to prevent seepage.

The rammed aggregate (stone) or vibro-replacement stone column soil improvement techniques to reduce the amount of settlements consists of a properly designed short aggregate pier system, such as the Vibro-piers or Geopier™ foundation system, that allows for founding the proposed structure on a shallow spread foundation. The system typically has a depth-to-diameter ratio of 2 to 2.5 and is made up of very stiff, densely compacted aggregate piers. The piers are constructed by forming a cavity in the soil matrix by drilling or similar excavation methods. The soil at the bottom of the cavity is pre-stressed and densified using a large tamper. Once the soil at the bottom of the cavity is pre-stressed, well-graded aggregate base stone is placed in the hole in 18-inch lifts and compacted, using a high energy tamping system until the hole is filled. The building’s slab and foundations then rest on the pier system. The short aggregate piers can typically be installed to depths in the range of 10 to 15 feet. A proposed depth of 12 feet should be used to ensure the aggregate piers are bearing in the dense native SGC soils.

Caissons should consist of drilled shaft foundations bearing in the dense to very-dense clayey sand zone. A minimum caisson tip depth of 20 feet (at grade structures) and 10 feet (1 Level below grade) below the finished floor elevations are recommended. Actual shaft lengths may be reduced to accommodate pier caps and/or grade beams. Design and construction should assume straight shaft caissons. Sloughing could occur in the sand layer resulting in concrete quantities higher than neat dimension calculations. A minimum shaft diameter of 30 inches is recommended to allow for cleaning and inspection. All caissons should be examined by a representative of the Geotechnical Engineer to verify cleaning, depth, dimensions and proper bearing strata. Straight shaft caissons may be "machine cleaned" provided the contractor can show the ability to adequately remove loose material. Adjacent caisson base (tip) elevations should not vary by more than 45 degrees.

A minimum allowable distance of 3 caisson diameters, center-to-center, is recommended between caissons for reasons of construction safety and to reduce axial group action. This limitation ensures that newly placed caissons are not damaged during the subsequent placement of adjacent caissons. This distance may be reduced to 2 diameters if one of the caissons has been in place for enough time to allow concrete to set and cure. A load bearing reduction factor of 0.7 should be applied to individual caissons within a proximity of two diameters, center-to-center, of each other. If adjacent caissons are of different diameters, an average of the diameters should be used for determining spacing. A separate set of reduction factors apply to lateral group action. These can be provided on request if needed. In addition, lateral load analysis using L-Pile can be provided on request at additional cost. All caissons should be examined by a representative of the Geotechnical Engineer to verify cleaning, depth, dimensions and proper bearing strata.
Continuous footings and stem walls should be reinforced to distribute stresses arising from small differential movements, and long walls should be provided with control joints to accommodate these movements. Reinforcement and control joints are suggested to allow slight movement and prevent minor floor slab cracking.

3.6 Lateral Pressures
The following equivalent fluid lateral pressure values may be utilized for the proposed construction.

<table>
<thead>
<tr>
<th>Active Pressures</th>
<th>35 pcf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrestrained Walls</td>
<td></td>
</tr>
<tr>
<td>At Rest</td>
<td>60 pcf</td>
</tr>
<tr>
<td>Restrained Walls</td>
<td></td>
</tr>
<tr>
<td>Passive Pressures</td>
<td></td>
</tr>
<tr>
<td>Continuous Footings</td>
<td>300 pcf</td>
</tr>
<tr>
<td>Spread Footings or Drilled Piers</td>
<td>350 pcf</td>
</tr>
<tr>
<td>Coefficient of Friction (w/passive pressure)</td>
<td>0.35</td>
</tr>
<tr>
<td>Coefficient of Friction (w/out passive pressure)</td>
<td>0.45</td>
</tr>
</tbody>
</table>

All backfill must be compacted to not less than 95 percent (ASTM D-698) to mobilize these passive values at low strain. Expansive soils should not be used as retaining wall backfill, except as a surface seal to limit infiltration of storm/irrigation water. The expansive pressures could greatly increase active pressures.

3.7 Fill and Backfill
Native fine grained clayey soils are considered suitable for use in general grading fills but should not be used in the top 12-inches of pad fill or as retaining wall backfill. The top 12-inches of pad fill should be completed with an approved low or non-expansive soil, either approved imported common borrow or select granular soil. The native soils below 8 feet are approved as low or non-expansive soil. If select granular soils are used, the 4 inches of under-slab aggregate base may be included as part of the top 18-inches. Otherwise, 18-inches of approved common borrow should be used in addition to the normal 4 inches of aggregate base.

It is preferred to use well graded granular soil for wall backfill. Successful backfill of basement level walls can be difficult to achieve given generally tight access. Placement and compaction must be carefully controlled in order to minimize the potential for post construction settlement should the backfill zone be subjected to water infiltration. Even the most well controlled fine grained fills such as the native soils could experience additional settlement on the order of one to two percent of the wall height, or more, if subjected to significant moisture increases. Using well-graded granular fill will reduce that settlement potential to ½
percent. Accordingly, it is recommended to design and construct a structural slab to span over the backfill zone in the most critical areas or reinforce and pin the landing/entry slabs to the building stem wall to span over the backfill zone. This will reduce the potential for the exterior slab dropping and creating a tripping hazard. Critical areas can be considered to include not only concrete walkways and slabs, but also concrete and asphaltic concrete paving. Paving over wall backfill zones should be detailed to minimize the effects of backfill settlement. Utility lines, especially gravity sewer/storm drain lines, should be avoided in this backfill zone except for perpendicular building service connections. Where critical piping sensitive to settlement is required, grade beams to transfer across the fill zone should be considered. Tree wells are not recommended in basement wall backfill.

A pre-construction meeting should be held prior to starting the basement wall backfill to discuss the staging process and the procedures used for backfilling, to help minimize the potential for basement wall backfill settlement.

If imported common fill for use in site grading is required, it should be examined by a Soils Engineer to ensure that it is of low swell potential and free of organic or otherwise deleterious material. In general, the fill should have 100 percent passing the 3-inch sieve and no more than 60 percent passing the 200 sieve. For the fine fraction (passing the 40 sieve), the liquid limit and plasticity index should not exceed 30 percent and 10 percent, respectively. It should exhibit less than 1.5 percent swell potential when compacted to 95 percent of maximum dry density (ASTM D-698) at a moisture content of 2 percent below optimum, confined under a 100 psf surcharge, and inundated.

Fill should be placed on subgrade which has been properly prepared and approved by a Soils Engineer. Fill must be wetted and thoroughly mixed to achieve optimum moisture content, ±2 percent. Fill should be placed in horizontal lifts of 8-inch thickness (or as dictated by compaction equipment) and compacted to the percent of maximum dry density per ASTM D-698 set forth as follows:

A. Building Areas
1. Below footing level 95 or 500 psi slurry
2. Below slabs-on-grade (non-expansive soils) 95
3. Below slabs-on-grade (expansive soils) 90-95 (max)
(Not recommended for the top 12-inches of at-grade pads)
B. Pavement Subgrade or Fill 95
C. Utility Trench Backfill 95
D. Aggregate Base Course
1. Below floor slabs 95
2. Below asphalt paving 100
E. Landscape Areas 90
3.8 Utilities Installation

Trench excavations for shallow utilities can be accomplished by conventional trenching equipment, although cobble laden soils may impede progress and require the use of heavier equipment. Trench walls may not stand near-vertical for the periods of time required to install utilities. Trenches penetrating looser sandy deposits may experience sloughing of side walls and necessitating cutting back of side slopes and/or shoring. Adequate precautions must be taken to protect workmen in accordance with all current governmental regulations.

Backfill of trenches above bedding zones may be carried out with native excavated material provided over-sized material (>3 inches) is first removed. This material should be moisture-conditioned, placed in 8 inch lifts and mechanically compacted. Water settling is not recommended. Compaction requirements are summarized in the "Fill and Backfill" section of this report.

3.9 Slabs-on-Grade

To facilitate fine grading operations and aid in concrete curing, a 4-inch thick layer of granular material conforming to the gradation for Aggregate Base Course (A.B.C.) as per M.A.G. Specification Section 702 should be utilized beneath the slab. Dried subgrade soils must be re-moistened prior to placing the A.B.C. if allowed to dry out, especially if native soils are used in the top 18 inches of the pad.

The native upper soils are capable of storing a significant amount of moisture, which could increase the natural vapor drive through the slab. Accordingly, if moisture sensitive flooring and/or adhesive are planned, the use of a vapor barrier or low permeability concrete should be considered. Vapor barriers should be a minimum 15-mil thick polyolefin (or equivalent), which meets ASTM E 1745 Class A specifications. Vapor barriers do increase the potential for slab curling and water entrapment under the slab. Accordingly, if a vapor barrier is used, additional precautions such as low slump concrete, frequent jointing and proper curing will be required to reduce curling potential and detailed to prevent the entrapment of outside water sources. Vapor barriers are not required below the lower basement level slabs.

3.10 Asphalt & Concrete Pavement

If earthwork in paved areas is carried out to finish subgrade elevation as set forth herein, the subgrade will provide adequate support for pavements. The location designation is for reference only. The designer/owner should choose the appropriate sections to meet the anticipated traffic volume and life expectancy. The section capacity is reported as daily ESALs, Equivalent 18 kip Single Axle Loads. Typical heavy trucks impart 1.0 to 2.5 ESALs per truck depending on load. It takes approximately 1200 passenger cars to impart 1 ESAL.
Table 3.10.1 - Pavement Sections

<table>
<thead>
<tr>
<th>Area of Placement</th>
<th>Flexible (AC Pavement)</th>
<th>Rigid (PCC Pavement)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thickness AC (0.39)</td>
<td>Daily 18-kip ESALs</td>
</tr>
<tr>
<td></td>
<td>Thickness ABC (0.12)</td>
<td></td>
</tr>
<tr>
<td>Auto Parking</td>
<td>2.0&quot;</td>
<td>4</td>
</tr>
<tr>
<td>Truck Parking, Main Drives, &amp; Fire Lanes</td>
<td>3.0&quot;</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>3.0&quot;</td>
<td>8.0&quot;</td>
</tr>
</tbody>
</table>

**Notes:**
1. Designs are based on AASHTO design equations and ADOT correlated R-Values.
2. The PCCP thickness is increased to provide better load transfer, and reduce potential for joint & edge failures. Design PCCP per ACI 330R-87.
3. Full depth asphalt or increased asphalt thickness can be increased by adding 1.0-inch asphalt for each 3 inches of base course replaced.

Pavement Design Parameters:
Assume: One 18 kip Equivalent Single Axle Load (ESAL)/Truck Life: 20 years
Subgrade Soil Profile:
% Passing #200 sieve: 62%
Plasticity Index: 4%
k: 150 pci (assumed)
R value: 36 (per ADOT tables)
Mr: 21,900 (per AASHTO design)

These designs assume that all subgrades are prepared in accordance with the recommendations contained in the "Site Preparation" and "Fill and Backfill" sections of this report, and paving operations carried out in a proper manner. If pavement subgrade preparation is not carried out immediately prior to paving, the entire area should be proof-rolled at that time with a heavy pneumatic-tired roller to identify locally unstable areas for repair.

Pavement base course material should be aggregate base per M.A.G. Section 702 Specifications. Asphalt concrete materials and mix design should conform to M.A.G. 710. It is recommended that a ½ inch or ¾ inch mix designation be used for the pavements. While a ¾ inch mix may have a somewhat rougher texture, it offers more stability and resistance to scuffing, particularly in truck turning areas. Pavement installation should be carried out under applicable portions of M.A.G. Section 321 and municipality standards. The asphalt supplier should be informed of the pavement use and required to provide a mix that will provide stability and be aesthetically acceptable. Some of the newer M.A.G. mixes are very coarse and could cause...
placing and finish problems. A mix design should be submitted for review to determine if it will be acceptable for the intended use.

For sidewalks and other areas not subjective to vehicular traffic a 4-inch section of concrete will be sufficient. For trash and dumpster enclosures a thicker section of 6 inches of concrete is recommended.

Portland Cement Concrete Pavement must have a minimum 28-day flexural strength 550 psi (compressive strength of approximately 3,700 psi). It may be cast directly on the prepared subgrade with proper compaction (reduced) and the elevated moisture content as recommended in the report. Lacking an aggregate base course, attention must be paid to using low slump concrete and proper curing, especially on the thinner sections. No reinforcing is necessary. Joint design and spacing should be in accordance with ACI recommendations. Construction joints should contain dowels or be tongue and grooved to provide load transfer. Tie bars are recommended on the joints adjacent to unsupported edges. Maximum joint spacing in feet should not exceed 2 to 3 times the thickness in inches. Joint sealing with a quality silicone sealer is recommended to prevent water from entering the subgrade allowing pumping and loss of support.

Proper subgrade preparation and joint sealing will reduce (but not eliminate) the potential for slab movements (thus cracking) on the expansive native soils. Frequent jointing will reduce uncontrolled cracking and increase the efficiency of aggregate interlock joint transfer.

4.0 GENERAL

The scope of this investigation and report includes only regional published considerations for seismic activity and ground fissures resulting from subsidence due to groundwater withdrawal, not any site specific studies. The scope does not include any considerations of hazardous releases or toxic contamination of any type.

Our analysis of data and the recommendations presented herein are based on the assumption that soil conditions do not vary significantly from those found at specific sample locations. Our work has been performed in accordance with generally accepted engineering principles and practice; this warranty is in lieu of all other warranties expressed or implied.
We recommend that a representative of the Geotechnical Engineer observe and test the earthwork and foundation portions of this project to ensure compliance to project specifications and the field applicability of subsurface conditions which are the basis of the recommendations presented in this report. If any significant changes are made in the scope of work or type of construction that was assumed in this report, we must review such revised conditions to confirm our findings if the conclusions and recommendations presented herein are to apply.

Respectfully submitted,
SPEEDIE & ASSOCIATES, INC.

Ray C. Markley, E.I.T.

Keith R. Gravel, P.E.

Gregg A. Creaser, P.E.
APPENDIX

FIELD AND LABORATORY INVESTIGATION

SOIL BORING LOCATION PLAN

SOIL LEGEND

LOG OF TEST BORINGS

TABULATION OF TEST DATA

CONSOLIDATION TEST RESULT

MOISTURE DENSITY RELATION

SWELL TEST DATA

DIRECT SHEAR TEST DATA

DRILLED SHAFT CAPACITY CHARTS
FIELD AND LABORATORY INVESTIGATION

On March 20, 2018 soil test borings were drilled at the approximate locations shown on the attached Soil Boring Location Plan. All exploration work was carried out under the full-time supervision of our staff engineer, who recorded subsurface conditions and obtained samples for laboratory testing. The soil auger borings were advanced with a truck-mounted CME-75 drill rig utilizing 7-inch diameter hollow stem flight augers. The hammer borings were advanced with a truck-mounted CME-75 utilizing the Tubex hammer drilling equipment. Detailed information regarding the borings and samples obtained can be found on an individual Log of Test Boring prepared for each drilling location.

Laboratory testing consisted of moisture content, dry density, grain-size distribution and plasticity (Atterberg Limits) tests for classification and pavement design parameters. Remolded swell tests were performed on samples compacted to densities and moisture contents expected during construction. Compression tests were performed on a selected ring sample in order to estimate settlements and determine effects of inundation. All field and laboratory data is presented in this appendix.
SOIL LEGEND

<table>
<thead>
<tr>
<th>SAMPLE DESIGNATION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>Auger Sample A grab sample taken directly from auger flights.</td>
</tr>
<tr>
<td>BS</td>
<td>Large Bulk Sample A grab sample taken from auger spoils or from bucket of backhoe.</td>
</tr>
<tr>
<td>S</td>
<td>Spoon Sample Standard Penetration Test (ASTM D-1586) Driving a 2.0 inch outside diameter split spoon sampler into undisturbed soil for three successive 6-inch increments by means of a 140 lb. weight free falling through a distance of 30 inches. The cumulative number of blows for the final 12 inches of penetration is the Standard Penetration Resistance.</td>
</tr>
<tr>
<td>RS</td>
<td>Ring Sample Driving a 3.0 inch outside diameter spoon equipped with a series of 2.42-inch inside diameter, 1-inch long brass rings, into undisturbed soil for one 12-inch increment by the same means of the Spoon Sample. The blows required for the 12 inches of penetration are recorded.</td>
</tr>
<tr>
<td>LS</td>
<td>Liner Sample Standard Penetration Test driving a 2.0-inch outside diameter split spoon equipped with two 3-inch long, 3/8-inch inside diameter brass liners, separated by a 1-inch long spacer, into undisturbed soil by the same means of the Spoon Sample.</td>
</tr>
<tr>
<td>ST</td>
<td>Shelby Tube A 3.0-inch outside diameter thin-walled tube continuously pushed into the undisturbed soil by a rapid motion, without impact or twisting (ASTM D-1587).</td>
</tr>
<tr>
<td><strong>--</strong></td>
<td>Continuous Penetration Resistance Driving a 2.0-inch outside diameter &quot;Bullnose Penetrometer&quot; continuously into undisturbed soil by the same means of the spoon sample. The blows for each successive 12-inch increment are recorded.</td>
</tr>
</tbody>
</table>

### CONSISTENCY

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>PARTICLE SIZE</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands</td>
<td>Fine</td>
<td>0.075</td>
<td>#200</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>0.420</td>
<td>#40</td>
</tr>
<tr>
<td></td>
<td>Coarse</td>
<td>2.000</td>
<td>#10</td>
</tr>
<tr>
<td>Gravels</td>
<td>Fine</td>
<td>4.75</td>
<td>#4</td>
</tr>
<tr>
<td></td>
<td>Coarse</td>
<td>19</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3&quot;</td>
</tr>
<tr>
<td>Cobble</td>
<td>75</td>
<td>3&quot;</td>
<td>300</td>
</tr>
<tr>
<td>Boulders</td>
<td>300</td>
<td>12&quot;</td>
<td>900</td>
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<td></td>
<td></td>
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<td>36&quot;</td>
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### RELATIVE DENSITY

<table>
<thead>
<tr>
<th>Clays &amp; Silts</th>
<th>Blows/Foot</th>
<th>Strength (tons/sq ft)</th>
<th>Sands &amp; Gravels</th>
<th>Blows/Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>0 - 2</td>
<td>0 - 0.25</td>
<td>Very Loose</td>
<td>0 - 4</td>
</tr>
<tr>
<td>Soft</td>
<td>2 - 4</td>
<td>0.25 - 0.5</td>
<td>Loose</td>
<td>5 - 10</td>
</tr>
<tr>
<td>Firm</td>
<td>5 - 8</td>
<td>0.5 - 1.0</td>
<td>Medium Dense</td>
<td>11 - 30</td>
</tr>
<tr>
<td>Stiff</td>
<td>9 - 15</td>
<td>1 - 2</td>
<td>Dense</td>
<td>31 - 50</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>16 - 30</td>
<td>2 - 4</td>
<td>Very Dense</td>
<td>&gt; 50</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt; 30</td>
<td>&gt; 4</td>
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### PARTICLE SIZE

<table>
<thead>
<tr>
<th>MATERIAL</th>
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<tbody>
<tr>
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<td>Coarse</td>
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<td>Gravels</td>
<td>Fine</td>
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<td></td>
<td>Coarse</td>
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<tr>
<td>Cobble</td>
<td></td>
</tr>
<tr>
<td>Boulders</td>
<td></td>
</tr>
</tbody>
</table>

**U.S. Standard Clear Square Openings**

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**Note:** Dual or modified symbols may be used to indicate borderline soil classifications or to provide a better graphical presentation of the soil.
**Visual Classification**

FILL: Medium Dense Brown SILTY GRAVEL with SAND (GM-Dry to Moist) with 1-10% Cobble

Very Dense, 1 to 5% Cobble at 5'

Auger Refusal on Cobbles

**Log of Test Boring Number:** B-1

**ASU Novus Parking Structure**

NWC University Drive & G Street

Tempe, Arizona

**Project No.:** 180516SA

---

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Depth of Sample</th>
<th>Natural Water Content (%)</th>
<th>In-Place Dry Density (P.C.)</th>
<th>Penetration Resistance Blows per Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1</td>
<td>2.5</td>
<td>NT</td>
<td>NT</td>
<td></td>
</tr>
<tr>
<td>S-2</td>
<td>6.5</td>
<td>NT</td>
<td>NT</td>
<td>61/12&quot;</td>
</tr>
</tbody>
</table>

**Boring Date:** 3-20-18

**Field Engineer/Technician:** J. Miller

**Driller:** R. Quezada

**Contractor:** Resilient Drilling

**Water Level**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Hour</th>
<th>Date</th>
<th>Free Water was Not Encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NT = Not Tested</td>
</tr>
</tbody>
</table>
Auger Refusal on Cobbles

FILL: Loose Brown CLAYEY SAND (SC-Dry to Moist) with Gravel, 1-10% Cobble

FILL: Dense Brown CLAYEY GRAVEL with SAND (GC-Dry) 1 to 5% Cobble

5 to 15% Cobble at 8'

Visual Classification

<table>
<thead>
<tr>
<th>Depth (feet)</th>
<th>Sample</th>
<th>Depth of Sample</th>
<th>Natural Water Content (%)</th>
<th>In-place Density (P.C.F.)</th>
<th>Penetration Resistance Blows per Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>S-1</td>
<td>2.5</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>6.5</td>
<td>S-2</td>
<td>6.5</td>
<td>NT</td>
<td>NT</td>
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Boring Date: 3-20-18
Field Engineer/Technician: J. Miller
Driller: R. Quezada
Contractor: Resilient Drilling

Water Level

<table>
<thead>
<tr>
<th>Depth</th>
<th>Hour</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Water was Not Encountered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NT = Not Tested</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Log of Test Boring Number: B-2

ASU Novus Parking Structure
NWC University Drive & G Street
Tempe, Arizona

Project No.: 180516SA
**Rig Type:** CME-75  
**Boring Type:** Hollow Stem Auger  
**Surface Elevation:** N/A  

**Visual Classification**

- **FILL:** Loose Brown POORLY GRADED GRAVEL with SAND (GP-Dry to Moist) with 1-10% Cobble
- Stiff Brown SANDY SILTY CLAY (CL/ML-Dry) with Trace Gravel
- Loose Brown SILTY SAND (SM-Dry) with Little Gravel
- Medium Dense
- Very Stiff Brown SANDY SILTY CLAY (CL/ML-Dry)
- Dense Brown WELL GRADED SAND (SW-Dry) with Little Gravel
- Very Dense Brown/Gray SILTY GRAVEL with SAND (GM-Dry) with 5-15% Cobble
- Auger Refusal on Cobbles

**Boring Date:** 3-20-18  
**Field Engineer/Technician:** J. Miller  
**Driller:** R. Quezada  
**Contractor:** Resilient Drilling

**Water Level**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Hour</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Water was Not Encountered</td>
<td>△</td>
<td></td>
</tr>
</tbody>
</table>

**Log of Test Boring Number:** B-3  
**ASU Novus Parking Structure**  
**NWC University Drive & G Street**  
Tempe, Arizona  
**Project No.:** 180516SA
<table>
<thead>
<tr>
<th>SOIL BORING or TEST PIT NUMBER</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE TYPE</th>
<th>SAMPLE INTERVAL (ft)</th>
<th>NATURAL WATER CONTENT (Percent of Dry Weight)</th>
<th>IN-PLACE DRY DENSITY (Pounds Per Cubic Foot)</th>
<th>PARTICLE SIZE DISTRIBUTION (Percent Finer)</th>
<th>ATTERBERG LIMITS</th>
<th>UNIFIED SOIL CLASSIFICATION</th>
<th>SPECIMEN DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>B-3</td>
<td>BS-2</td>
<td>BULK</td>
<td>0.5 - 5.0</td>
<td>NT</td>
<td>NT</td>
<td>62 99 99 100 100</td>
<td>24 20 4</td>
<td>CL-ML</td>
<td>SANDY SILTY CLAY</td>
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<tr>
<td>B-3</td>
<td>RS-1</td>
<td>RING</td>
<td>1.0 - 2.0</td>
<td>10.0</td>
<td>93.3</td>
<td>NT NT NT NT NT</td>
<td>NT NT NT</td>
<td>ML</td>
<td>SILT with SAND</td>
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<tr>
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<td>RS-3</td>
<td>RING</td>
<td>10.0 - 11.0</td>
<td>8.3</td>
<td>88.4</td>
<td>83 99 100 100 100</td>
<td>28 23 5</td>
<td>ML</td>
<td>SANDY SILT</td>
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<tr>
<td>B-4</td>
<td>RS-4</td>
<td>RING</td>
<td>15.0 - 16.0</td>
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<td>NT</td>
<td>63 87 96 100 100</td>
<td>25 22 3</td>
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<td>SANDY SILT</td>
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<tr>
<td>B-4</td>
<td>RS-5</td>
<td>RING</td>
<td>20.0 - 21.0</td>
<td>NT</td>
<td>NT</td>
<td>6 6 16 22 100</td>
<td>NP NP NP</td>
<td>GP-GM</td>
<td>POORLY GRADED GRAVEL with SILT and SAND</td>
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</tbody>
</table>

Sieve analysis results do not include material greater than 3". Refer to the actual boring logs for the possibility of cobble and boulder sized materials.

NT=Not Tested

ASU Novus Parking Structure
NWC University Drive & G Street
Tempe, Arizona
Project No. 180516SA
CONSOLIDATION TEST

PROJECT: ASU Novus Parking Structure
LOCATION: NWC University Drive & G Street
BORING NO.: B-3 SAMPLE NO.: RS-1 SAMPLE DEPTH: 1 to 2
LIQUID LIMIT: PLASTIC LIMIT: PLASTICITY INDEX:
CLASSIFICATION: ASTM SOIL DESCRIPTION:

Sample inundated at end of test at 6400 psf
CONSOLIDATION TEST

PROJECT: ASU Novus Parking Structure  PROJECT NO.: 180516SA
LOCATION: NWC University Drive & G Street  DATE: 3/20/18
BORING NO.: B-4  SAMPLE NO.: RS-3  SAMPLE DEPTH: 10 to 11  LABORATORY NO.: 
LIQUID LIMIT: 28  PLASTIC LIMIT: 23  PLASTICITY INDEX: 4
CLASSIFICATION: ML  ASTM SOIL DESCRIPTION: SILT with SAND

Sample inundated at end of test at 12800 psf

DRAFT
MOISTURE-DENSITY RELATIONS

PROJECT: ASU Novus Parking Structure  PROJECT NO.: 180516SA
LOCATION: NWC University Drive & G Street  DATE: 3/20/18
BORING NO.: B-3  SAMPLE NO.: BS-2  SAMPLE DEPTH: 0.5 to 5
METHOD OF COMPACTION: D698A  LABORATORY NO.: 

LIQUID LIMIT: 24  PLASTIC LIMIT: 20  PLASTICITY INDEX: 4
CLASSIFICATION: CL-ML  ASTM SOIL DESCRIPTION: SANDY SILTY CLAY

MAXIMUM DRY DENSITY: 116.5 PCF  OPTIMUM MOISTURE CONTENT: 11.0%

DRAFT
# SWELL TEST DATA

<table>
<thead>
<tr>
<th>BORING or TEST PIT No.</th>
<th>SAMPLE DEPTH, ft</th>
<th>MAXIMUM DRY DENSITY (pcf)</th>
<th>OPTIMUM MOISTURE CONTENT (%)</th>
<th>REMOLDED DRY DENSITY (pcf)</th>
<th>INITIAL MOISTURE CONTENT (%)</th>
<th>PERCENT COMPACTION</th>
<th>FINAL MOISTURE CONTENT (%)</th>
<th>CONFINING LOAD (psf)</th>
<th>TOTAL SWELL (%)</th>
</tr>
</thead>
<tbody>
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<td>B-3, BS-2</td>
<td>5.0</td>
<td>116.5</td>
<td>11.0</td>
<td>110.4</td>
<td>9.5</td>
<td>94.8</td>
<td>18.1</td>
<td>100</td>
<td>2.1</td>
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ASU Novus Parking Structure  
NWC University Drive & G Street  
Tempe, Arizona  
Project No. 180516SA
Drilled Shaft Axial Capacity
At-Grade Structures

Allowable Axial Capacity, kips

Depth Below Grade, ft

Project No. 180516SA
Tempe Parking Garage

- Diameter 2'
- Diameter 2.5'
- Diameter 3'
- Diameter 4'

SPEEDIE AND ASSOCIATES
Drilled Shaft Uplift Capacity
At-Grade Structures

Allowable Uplift Capacity, kips

Depth Below Grade, ft

Project No. 180516SA
Tempe Parking Garage

- Diameter 2'
- Diameter 2.5'
- Diameter 3'
- Diameter 4'
Drilled Shaft Axial Capacity
with 1 Level Below Grade

Allowable Axial Capacity, kips

Depth Below Lower Level Grade, ft

Project No. 180516SA
Tempe Parking Garage

Diameter 3'
Diameter 4'
Diameter 5'
Diameter 6'
Drilled Shaft Uplift Capacity with 1 Level Below Grade

Allowable Uplift Capacity, kips

Depth Below Lower Level Grade, ft

Project No. 180516SA
Tempe Parking Garage

Diameter 3'
Diameter 4'
Diameter 5'
Diameter 6'