WHITCHURCH ENGINEERING

610 9th Street
Fortuna, CA 95540
Phone: (707) 725-6926

November 10th, 2020

True North Construction
c/o Mike Folk
PO Box 554
Corte Madera, CA 94925

RE: Underground Culvert Structural Analysis
Undeveloped property
Brookdale Ave
San Rafael, CA

JN: TNC2001

Dear Mr. Folk,

Per your request, our firm performed an evaluation of an underground culvert located partially on the above-mentioned property between Brookdale Ave. and Lincoln Ave. in San Rafael, CA. The purpose of the evaluation was to determine if the land could be developed with the culvert in place, what measures might need to be taken to protect it during construction, and if the culvert had the required structural capacity to support an increased demand with a proposed parking lot above it. Our evaluation consisted of a site visit, scanning for reinforcement in the concrete, and a structural analysis of the culvert for construction and proposed future loading. No as built or design drawings of the culvert were available for my review, all of the design information gathered was based on the visual inspection and scanning for steel reinforcement.

Site Visit

On September 2nd, 2020, I met you at the property location to perform a physical investigation of the culvert. The underground culvert begins at a creek to the North of the property location and travels almost directly South, underneath the property in question and the neighboring properties, and terminates at a headwall in a creek to the south of the property. Attachment 1 is the informal survey provided to me by yourself before our site visit showing the approximate location of the culvert with respect to Brookdale Ave. and the surrounding properties.

From the site visit, it was apparent from varying culvert shape and construction techniques that the portion of the culvert underneath your property was constructed at a different date than the Northernmost portion of the culvert. The Northern portion of culvert has an approximately six-foot-high, arched roof, the portion underneath your property has an approximately five-foot-high, flat roof and appears to be less worn than the northern portion. For the purposes of our evaluation, I will focus solely on the portion of the culvert underneath your property.

Attachment 2 shows photos taken from the site visit of the underground culvert beneath your property. The culvert is approximately 4.5 feet wide and 5 feet high with concrete walls on all four sides. To allow for inflow of water, certain areas of the culvert have small openings, these openings are all currently blocked off, however, I was able to measure the thickness of the concrete walls at these locations. The concrete wall is approximately 6 inches thick. To check for reinforcement, I used a GSSI M:SSMINI Structure Scan Mini, to scan for steel reinforcement in the walls and roof. From the scan, I found reinforcement in the walls and roof at 18" o/c in both

directions. From the scan and from some areas of exposed reinforcement, I estimated the rebar to be ½" diameter, #4 rebar.

From my visual inspection of the culvert, the structure shows no signs of failure due to loading or seismic movement. There are areas where the reinforcement is exposed and corroded, however, these areas would appear to be from flaws in the initial construction and not structural failure of the culvert. This conclusion is based on the lack of cracking at the areas of failure which would indicate failure from loading or deformation. Throughout the entire area of culvert inspected, I witnessed only minor cracking likely caused by temperature shrinkage or other common, non-detrimental causes.

Structural Analysis

To determine the capacity of the culvert to resist an increase of loads from the development of the property, I performed a structural analysis based on the information gathered from the site visit. I applied two separate load conditions, the first was with three feet of soil on top of the culvert and a 16,000 lb. point load from the rear tire of a Caltrans H20 trucking load, and the second was with three feet of soil and an 8,000 lb. point load from the American Society of Civil Engineers Standard 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, for sidewalks, vehicular driveways, and yards subject to trucking. The first load is assumed to be the max load during construction while the second load is the maximum load once the property is developed. The point loads are modeled as dispersing through the soil at a 1:1 ratio, creating a distributed load across the top of the culvert. Attachment three is the calculation package showing the rest of the design assumptions and conditions.

From the analysis, the soil plus construction load created a higher ultimate demand than the expected capacity of the culvert. To lower the demand on the culvert, 1 inch thick, 8-foot-wide steel plates need to be laid over the culvert, on top of the soil, wherever any machinery is expected to cross over it. The 1 inch thick, 8-foot steel plates plus the 3 feet of soil will disperse the load and lower the demand on the culvert to less than the capacity. The 8,000-pound load plus the soil did not exceed the required demand to capacity ratio of the culvert. With the expected addition of Asphalt Concrete or regular concrete anywhere that trucks will be driving or heavy point loads may occur, I do not anticipate any issues with the culvert from the proposed development. This includes the possibility of two car loading scenarios with car lifts.

Conclusion

From my analysis, site visit, and scanning for steel reinforcement, I conclude that the existing culvert can remain in place during construction and development of the above-mentioned property. Some steps need to be taken to ensure the continued structural integrity of the culvert. Those steps are:

1. Hire a licensed contractor to repair the portions of the culvert where the wall has been compromised. At a minimum the repair should include the removal of corrosive scale around the steel reinforcement and patching of the wall using grout or a similar bonding agent that will help protect the reinforcement from further corrosion.
2. Place 1" thick steel plates over top of the culvert during construction. Steel plates should be centered on the culverts and be a minimum of eight feet wide, measured perpendicular to the culverts flow direction.
3. Perform periodic inspections of the culvert during construction when machinery is on-site and operating over top of the culvert (on the 1" steel plates). Periodic inspections should also be performed after major rain events and seismic events.

While the culvert is in good shape for its projected age, it is still getting close to its projected service life. The steps above will help preserve the culvert but cannot reverse or halt the aging process. I recommend that periodic inspection of the culvert continue even after construction. The inspections should look for cracking and spalling of concrete to indicate failure of the culvert walls or roof. The presence of ample steel reinforcement in the culvert indicates that failure of the culvert should be noticeable before collapse and alternative measures such as adding a pipe to carry water flow and backfilling of the culvert can be taken.

I assume that competent construction methods were used in the construction of the culvert. These assumptions are supported by the apparent condition of the culvert; however, I cannot guarantee the quality of construction nor can I guess at the expected life of the culvert. All best management practices should be taken to protect and prolong the life of the culvert.

Please contact me if you have any questions.

Sincerely,

11/13/20

Brett Whitchurch, M.S, P.E
Associate Engineer
RCE#90914

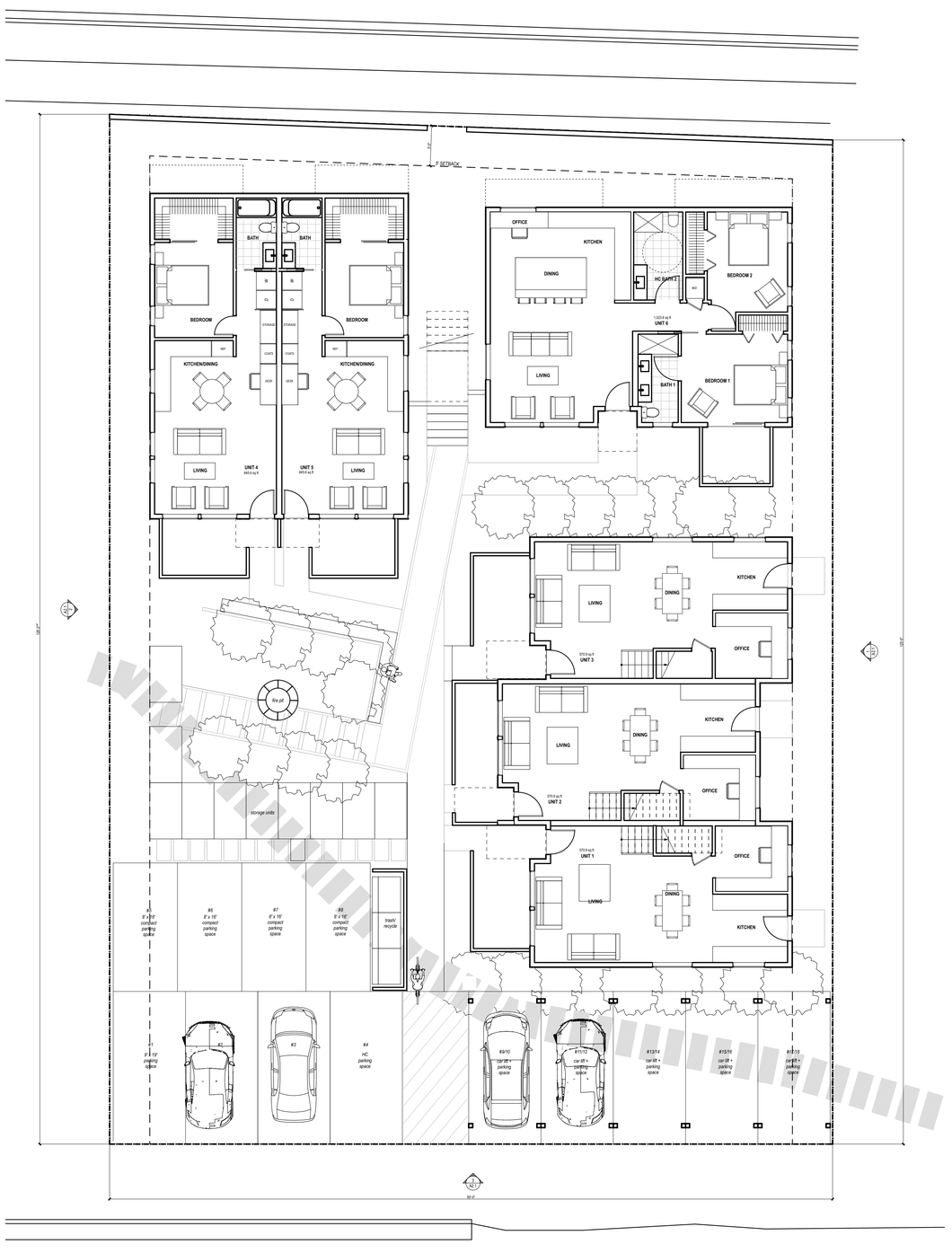
Attachment:

1. Attachment 1 – Approximate layout of underground culvert
2. Attachment 2 – Pictures from Site Visit
3. Attachment 3 – Calculation Package

QC

LINCOLN AVENUE

A1.1



BROOKDALE AVENUE

1
A1.1

PROPOSED FIRST FLOOR PLAN

SCALE: 1/8" = 1'-0"

REFERENCE NORTH

TRUE NORTH

0' 8' 16'

SCALE: 1/8"=1'-0"

POLSKY PERLSTEIN ARCHITECTS
4698 Magnolia Avenue
Larkspur, CA 94939
Phone 415 927 1345
Fax 415 927 1848
www.polskyarchitects.com

BROOKDALE APARTMENTS

STREET NAME
CITY CA
AP# XXX-XXX-XX

PRELIMINARY

DATE	Δ	DESCRIPTION	BY
06 JUL 2014		DESIGN REVIEW SUBMITTAL	PA

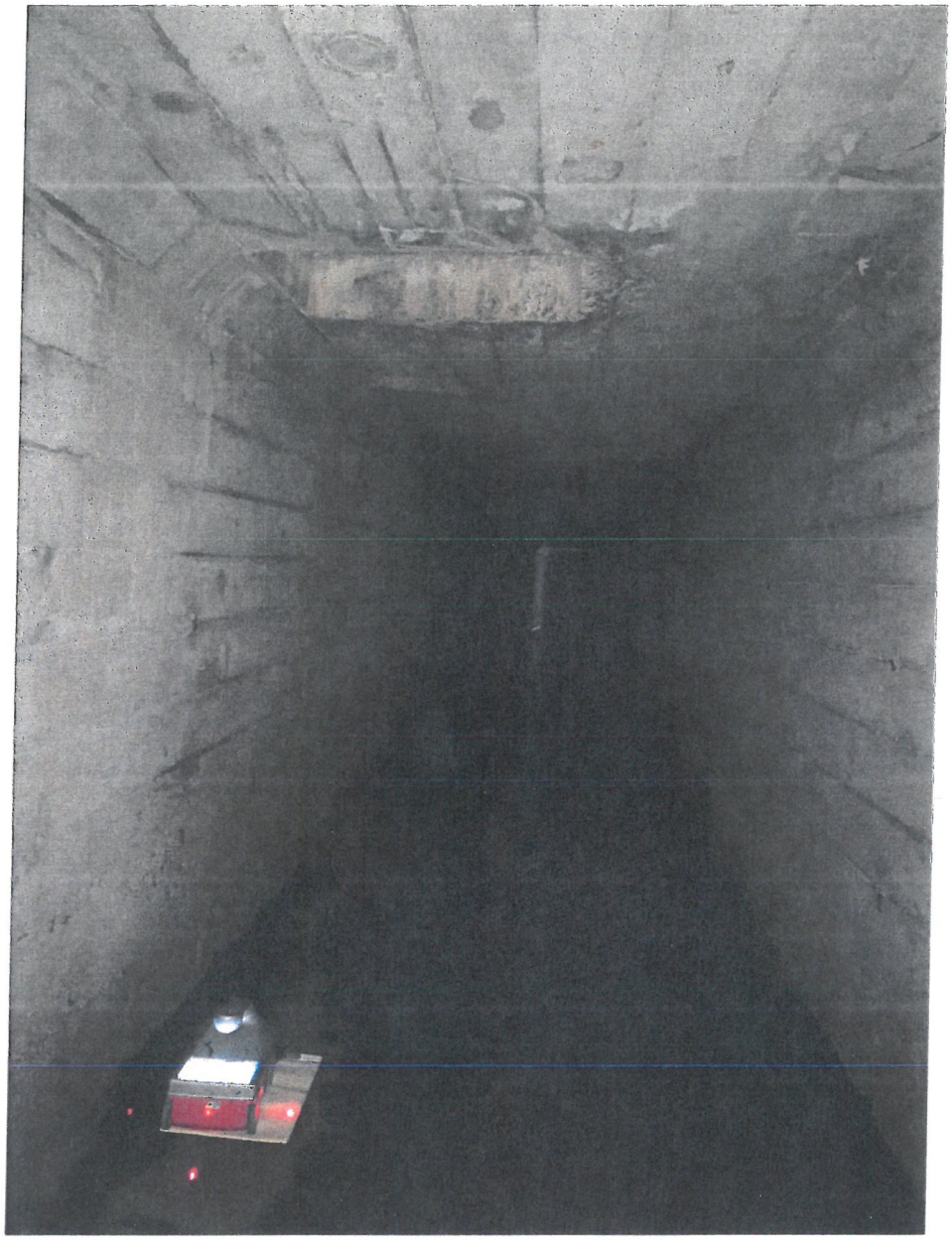
PRINT DATE	11/17/20
DRAWN	PA
JOB #	20XX
SCALE	NOTED

PROPOSED FIRST FLOOR PLAN

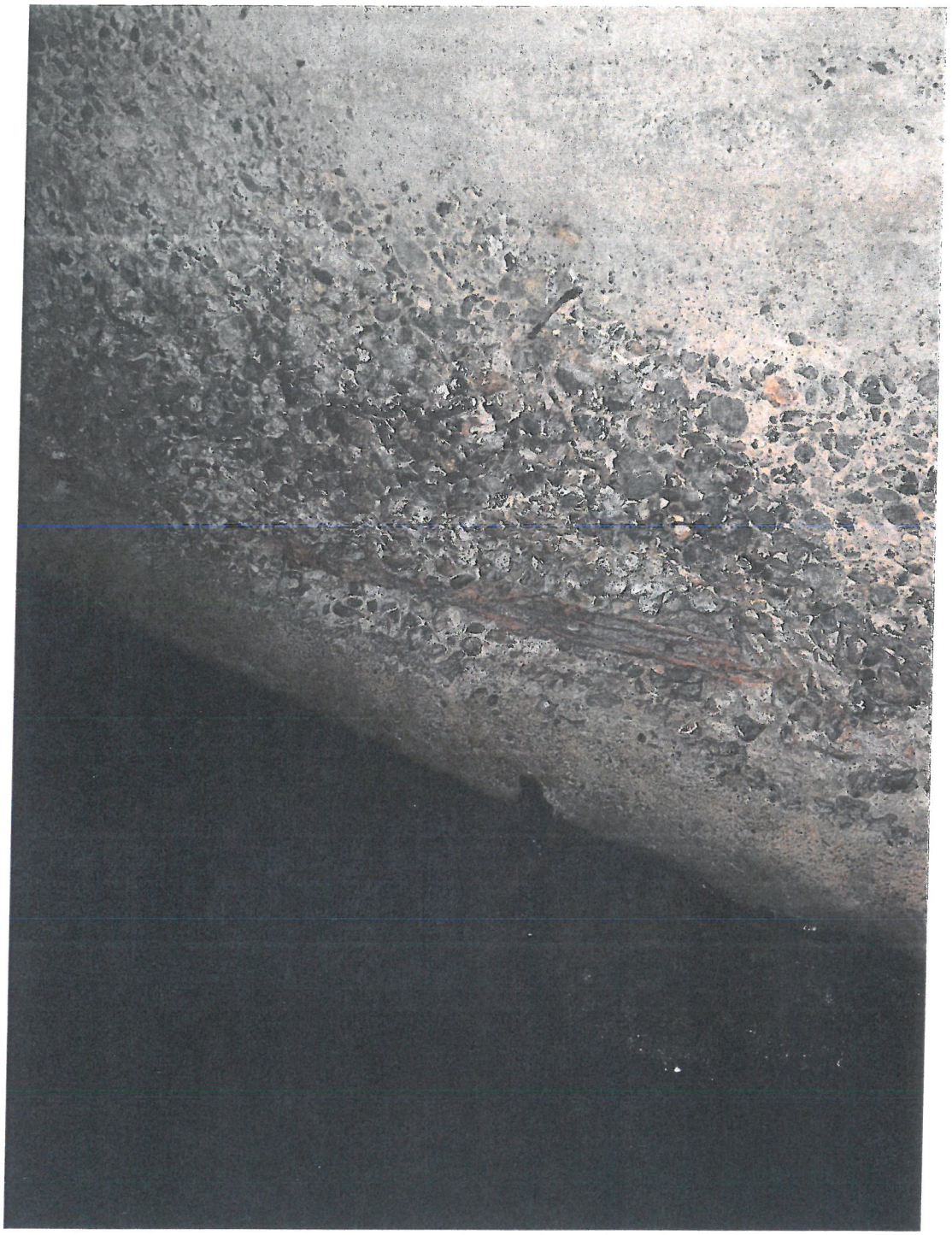
SHEET

A1.1

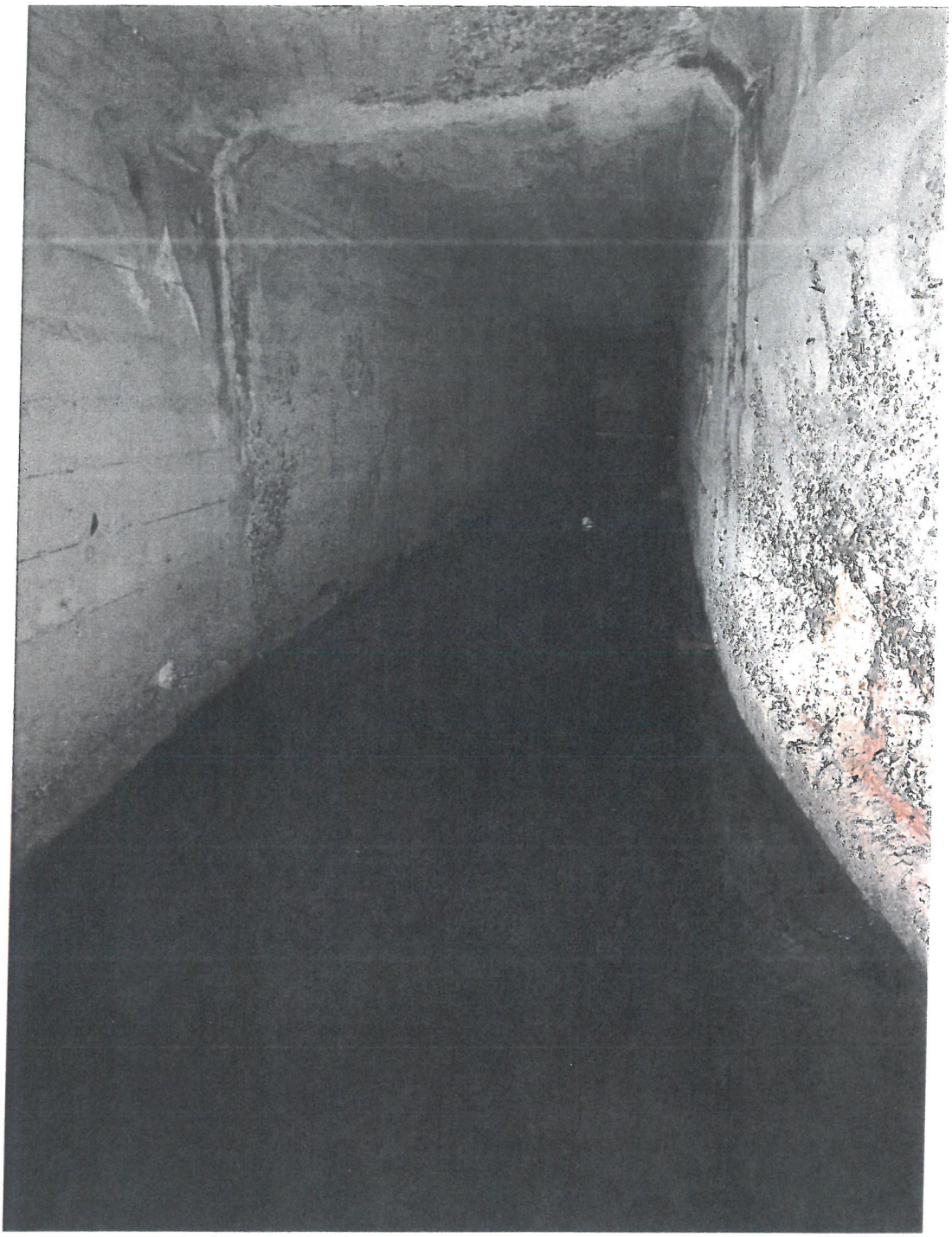
ATTACHMENT 2



Picture from inside the culvert. Blocked access hole shown in roof



Case of spalled concrete and corroded reinforcement. This was the worse spot identified, however, there was no evidence of cracking around the area which would indicate wall failure. Spots like this need to be repaired by a licensed contractor.



Another picture of the culvert. On the right is another location of concrete spalling and reinforcement corrosion. This area of spalling shows the vertical reinforcement as well as the horizontal. Once again, the problem area shows no indication of cracking but does need to be repaired.

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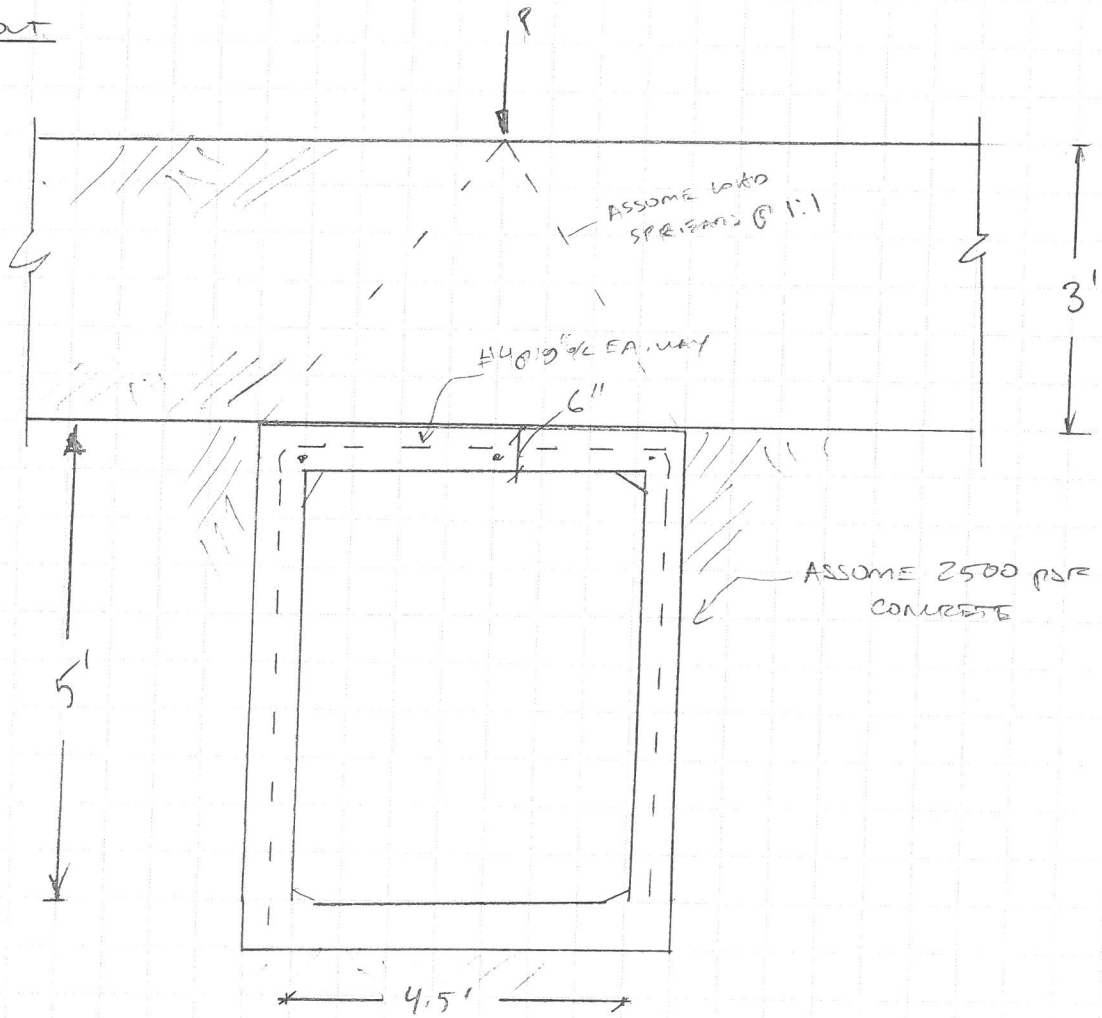
JOB TRUE NORTH CONSTRUCTION
ELEMENT UNDERGROUND CULVERT
SHEET NO. 1 OF 2
CALCULATED BY BLW DATE 10/5/20
CHECKED BY JN TNC 2001

SCOPE: CHECK EXISTING UNDERGROUND CULVERT FOR SOIL LOADS + CONSTRUCTION LOADS

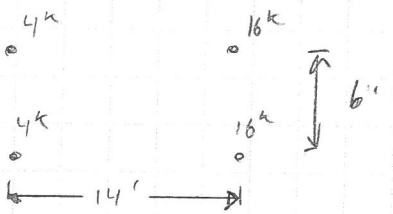
LAYOUT



LOADS SOIL LOAD : ASSUME 120 PCF SOIL

CONSTRUCTION LOAD: ASSUME MAX TRUCK LOADING = H 20

H 20:



PERMANENT LOAD = 8000# POINT LOAD — SIDEWALKS, VEHICULAR DRIVEWAYS, AND YARDS SUBJECT TO TRUCKING ASCE 7-16 TABLE 4.3-1

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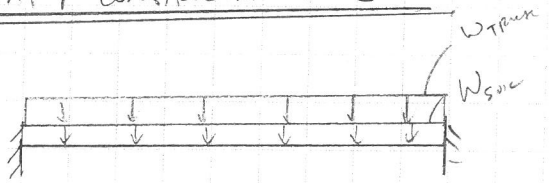
JOB TRUE NORTH CONSTRUCTION
ELEMENT UNDERGROUND CULVERT
SHEET NO. 2 OF 2
CALCULATED BY [illegible] DATE 10/5/20
CHECKED BY JN TNC 2001

CHECK TOP OF CULVERT:

TEMPORARY CONSTRUCTION LOAD



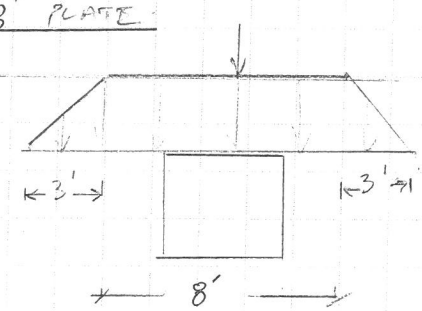
$W_{soil} = 120\ PCF \cdot 3' \cdot 1^{4}/_{4} = 360\ PCF/ft$

$W_{TRUCK} = 16{,}000^{\#}/6' \cdot 6' = 444\ PSF$

$M_u = \frac{wl^2}{12} = \frac{(1.2 \cdot 360 + 1.6 \cdot 444) \cdot (4.5')^2}{12} = 1.9^{k-ft}$

$\phi M_n = 1.7^{k-ft}$ ~~M_u~~ NOT OK

TRY W/ 8' PLATE



$W_{TRUCK} = 16{,}000^{\#}/14' \cdot 6'' = 190\ PSF$

$M_u = \frac{wl^2}{12} = \frac{(1.2 \cdot 360 + 1.6 \cdot 190) \cdot (4.5)^2}{12} = 1.2^{k-ft}$

$\phi M_n = 1.7 > 1.2$ $\phi M_n > M_u$ OK W/ 8' PLATE

Thickness	6
Width (b)	12
Steel Depth (d)	3
f_y (ksi)	60
f'_c (ksi)	2.5
Area of Conc. (A_c)	36
Solver	
A_s	0.133 $^{k-in}$
ϕM_n (A_s)	20.41886

$\phi M_n = 20.4/12 = 1.7^{k-ft}$

CHECK FOR LIFETIME LOADING

CHECK 8,000# POINT LOAD PER ASCE 7-16, TABLE 4.3-1

$W_{soil} = 360\ PSF/ft$

$W_{TRUCK} = 8{,}000^{\#}/(6' \cdot 6') = 222\ PSF/ft$

$M_u = \frac{(1.2 \cdot 360 + 1.6 \cdot 222) \cdot (4.5')^2}{12} = 1.3^{k-ft}$

$\phi M_n = 1.7^{k-ft} > 1.3^{k-ft}$

CULVERT ADEQUATE FOR PARKING LOT LOAD W/O PLATING