August 16, 2007

Douglas County Public Works
100 3rd Street
Castle Rock, Colorado 80104

Attention: Mr. Matthew Williams, P.E.

Subject: Preliminary Findings
Geotechnical Consultation
Surface Drainage and Sidewalk Chase Drains
Highlands Ranch Filing No. 122-U
Highlands Ranch, Colorado
Project No. DN42,518-145

CTL | Thompson, Inc. was requested to evaluate possible factors causing excessive surface drainage across sidewalks and the need for chase drains for portions of Highlands Ranch, Filing Nos. 122-U, 122-X and 120-C. We understand homeowners in portions of these sites have complained of water flow across sidewalks that results in algae growth in the summer and ice formation in the winter. Some areas of ponded water have also been observed behind sidewalks. There have been requests for chase drains to allow water to flow from behind sidewalk areas into gutters. There have also been some instances of frequent pumping of foundation drain sump pits. We have been provided with data for portions of Filing Nos. 120-C, 122-U and 122-X that have experienced these concerns. At this time, we have evaluated available data for Filing No. 122-U. This letter presents our preliminary observations, conclusions and recommendations.

REVIEWED DOCUMENTS

As part of our investigation, Douglas County provided the following documents concerning Filing 122-U for our review:

1. Site grading plans by JR Engineering, Ltd (Project No. 43464.00, dated July 7, 2000.)

2. Overall Drainage and Erosion Control plans by JR Engineering, Ltd (Project No. 43464.00, dated August 25, 2000.)

3. Soil and Foundation Study letters by A.G. Wassenaar, Inc. for Lots 103 through 155 and 162 through 201 (Various project numbers, letters dated July 30, 2002 through September 28, 2004).

4. Residential water use records provided by Highlands Ranch Metro District from January through December, 2005.

5. Maps showing locations where chase drains were installed, prepared by Douglas County Public Works.

6. Aerial photograph of the study area showing chase drains installed and property lines prepared by Douglas County Public Works.

In addition to these documents, we also reviewed our "Consultation for Potential Sub-Excavation for Lots 1-102, Highlands Ranch, Filing No. 122-U" prepared for Shea Homes (Job No. 31,040; report dated May 1, 2000) and a Soils and Foundation Investigation for these 102 lots within Filing No. 122-U (Job No. 33,537; report dated October 19, 2001) performed for Shea Homes after site grading and sub-excavation. Pertinent data were considered during preparation of this report.

SITE CONDITIONS

On March 27, 2007 our Mr. Nan-Ping Hsieh, P.E. and Mr. Bill Rethamel, P.E. met with Mr. Williams at the site to observe conditions in Filing Nos. 122-U, 122-X and 120-C. Our observations in the filings were limited to areas designated by Douglas County Public Works. The study area for Filing No. 122-U is shown on Fig. 1, and includes 195 lots (Lots 1-155 and Lots 162-201). Most of these lots investigated by our firm were sub-excavated during land development. Based on grading plans, 58 lots were graded for walkout or garden level basement construction. One and two-story, single-family residences with attached garages were constructed after grading. The residences were constructed with foundation drains furnished with sump pits. We observed many residences had piped discharge lines from the sump pits to the swale. The majority of the discharge lines observed extended to the swales. Our experience indicates area drains may have been installed beneath sanitary sewer mains in the streets. Typically, foundation drains are not connected to the area drains. The lots are landscaped with irrigated grass and shrubs, with occasional trees. Some lots also have areas of landscaping rock. The site is surrounded by residential development. Big Dry Creek is located along the east side of Filing 122-U. An elementary school is to the north, across Poston Parkway. This portion of Filing No. 122-U generally slopes to the north and northeast. The lots in the southwestern portion of the study area (Lots 105-201) are higher than the lots to the northeast and east. Total relief across the site is about 122 feet, or approximately elevations 6172 to 6050.

At the time of our initial site visit on March 27, 2007, landscaping irrigation had not yet begun. There had been rain in the area during the prior week. We observed most of the landscaping on the lots in Filing No. 122-U was healthy and appeared to be growing. In several locations, very moist to wet areas were observed in the front lawns, along with water flow over the sidewalk (Photo 1). We also observed several areas of water flow and algae growth (Photo 2). Chase drains (Photo 3) had been constructed within the sidewalk in some areas to allow water to flow from behind the sidewalk to the curb.

Photo 1 - Water flow across sidewalk

Photo 2 - Water flow and algae growth

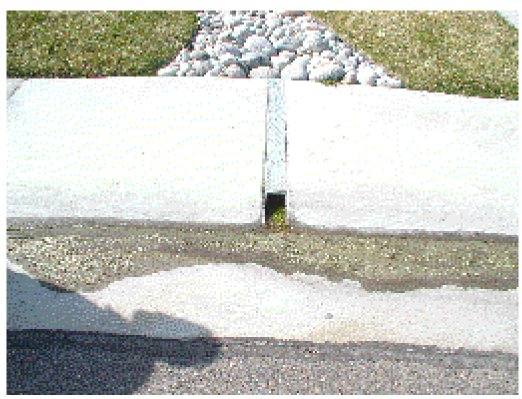


Photo 3 - Typical chase drain

PREVIOUS INVESTIGATIONS

CTL | Thompson, Inc. prepared a “Consultation for Potential Sub-Excavation for Lots 1-102, Highlands Ranch, Filing No. 122-U” for Shea Homes (Job No. 31,040; report dated May 1, 2000). A total of 35 borings were drilled within the study area between March 15 and 29, 2000. The borings ranged in depth from 15 to 40 feet. Subsoils encountered consisted of clay and clayey sand underlain by claystone, sandstone and interbedded claystone and sandstone. Ground water was not encountered in the borings performed during that investigation. Our report identified moderate to very high swelling soils and bedrock at the site. To mitigate the risk of swelling and expansive soils and bedrock, Shea Homes elected to sub-excavate and replace the soils and bedrock to a depth of at least 16 feet below the building envelope areas as moisture-conditioned, compacted fill. Sub-excavation was not performed on lots where 15 feet or more of fill was planned (Lots 18-20, Lots 23-27 and Lots 72-75).

After sub-excavation and site grading were performed, we performed a Soils and Foundation Investigation for Lots 1 through 102 within Filing No. 122-U (Job No. 33,537; report dated October 19, 2001). One boring was drilled on each of the 102 lots between August 15 and October 3, 2001. Subsoils encountered consisted of sub-excavation and site grading fill composed of clay and sand with bedrock fragments underlain by claystone, sandstone and interbedded claystone and sandstone. Ground water was not found in any of these 102 borings drilled to depths of 20 to 35 feet deep.

A.G. Wassenaar, Inc. performed soil and foundation studies for 97 lots (Lots 103-155 and Lots 162-201; under various project numbers, letters dated July 30, 2002 through September 28, 2004). Sub-excavation was not performed on these 97 lots. Wassenaar also drilled one test hole on each lot. Site grading fill ranging in thickness from 1 to 13 feet was encountered in 39 of their borings. Bedrock was encountered in all borings from the surface to depths of up to 17 feet. Ground water was either measured or encountered at depths of 6 to 24 feet in the test holes on 28 lots.

Depth of fill based on studies performed by our firm and A.G. Wassenaar is shown on Fig. 2. Depth to bedrock and estimated bedrock surface elevation are presented on Figs. 3 and 4, respectively. Measured depth to ground water is shown on Fig. 5. Estimated ground water surface elevation is shown on Fig. 6.

OBSERVATIONS AND ANALYSES

Based on our experience, we have considered the following factors in an attempt to evaluate whether they may have contributed to excessive surface runoff across sidewalks, and need for chase drains.

- Ground water levels before residence construction
- Sub-excavation and site grading
- Depth to bedrock
- Local surface drainage, such as lot drainage types (i.e. "A", "B" or walkout lots)
- Overall surface drainage, such as whether a lot is situated at the base of a slope (about 6 feet of grade change) or lower portion of the block
- Outdoor water use

We have summarized the data from our analyses and observations for those lots where chase drains were installed (Fig. 1) in Filing 122-U as shown in Tables I through III.

Ground Water and Source of Excessive Surface Water

As part of our analyses of potential sources of water, both ground water and surface water were considered. The studies performed by our firm for Lots 1-102, in the northeastern half of the subdivision did not indicate ground water was present at depths between 15 and 40 feet before site grading and 20 to 35 feet deep immediately after site grading and sub-excavation. At the time of both our and A.G. Wassenaar's investigations, elevations of the borings were not available. For the sub-excavated portion of the filing (Fig. 2), we judge ground water is probably at depths unlikely to be contributing to flow across sidewalks.

Unlike the lots to northeast, ground water was encountered under some lots in the southwestern half of the site. A.G. Wassenaar encountered water in 28 borings at depths of 6 to 24 feet below ground surface during their investigation after site grading. The ground water measurements performed by A.G. Wassenaar indicate that ground water is predominantly below the bedrock surface (Figs. 3 through 6). It appears the water was flowing within the bedrock to the north and northeast. Our experience indicates ground water may flow or "perch" in comparatively permeable sandstone and above less permeable claystone bedrock surface. Where bedrock daylights to the surface as the result of site grading, it is possible ground water may seep out of the cut slopes, and contribute to surface runoff. We were not able to observe seepage as the slopes were covered by both landscaping and retaining walls.

For the 51 locations on 71 lots where chase drains were installed in Filing 122-U, ground water was encountered under only three lots (Lots 197, 198 and 200, Table I) at depths of 10 to 12 feet after site grading and before residence construction. The data indicates the source of excessive surface water that occurred after construction of the residences is not from pre-existing springs or ground water. Our experience indicates the source of surface water is predominantly from precipitation events and landscaping watering after development.

We acknowledge that surface water can infiltrate and seep into the ground and become "ground water". This occurs frequently around a residence where backfill is more permeable and surface runoff can infiltrate through the backfill to the bottom of the basement excavation. The infiltrated water is then collected by a foundation drain and pumped to the ground surface. It is difficult to clearly differentiate whether the source of water is originating from ground water or surface water.

Sub-Excavation

For the 71 lots where chase drains were installed in Filing 122-U (Tables I and II), 50 lots (about 70 percent) had been sub-excavated. Our experience indicates sub-excavation fill is generally less permeable than native overburden soils and some of the weathered or fractured bedrock and clean sandstone bedrock. Sub-excavation disrupts the continuity of the permeable soil layers, strata or paths that seepage tends to follow, thus it probably creates a less

permeable stratum within the upper 16 feet or more of the ground surface. This probably tends to reduce surface water infiltration and increases the surface runoff.

The basement wall backfill is generally more permeable than the sub-excavation fill. Water can infiltrate through the backfill to the bottom of the basement excavation. The infiltrated water is then collected by the foundation drain and pumped to the ground surface. This increases the quantity of water in the swales and the potential need for chase drains.

Bedrock Depth

Our experience indicates ground water may flow or perch in comparatively permeable sandstone and above less permeable claystone bedrock surface. As shown in Table I, the bedrock depth under these 51 chase drain locations varies from at the ground surface to greater than 16 feet. The data does not reflect a conclusive correlation between the bedrock depth to the excessive surface runoff or the need for chase drains. It is possible that if seepage is intercepted by a basement excavation, water will be collected by the foundation drain and then pumped to the ground surface.

Local Surface Drainage – Lot Type

Surface drainage patterns affect the quantity water in the swales. The lots in Filing 122-U include Types "A", "B", "T", "G" and "W" with different surface drainage layouts.

- **Type "A" lots are graded to direct surface drainage to the front of the lot**
- **Type "B" lots are graded to direct surface drainage to the front and rear of the lot**
- **Type "T" lots are transition lots that are graded to direct surface drainage on one side to the front, and on the other side to both the front and rear portions of the lot**
- **Type "G" lots are graded to allow garden level basement construction**
- **Type "W" lots are graded to allow walkout basement construction**

For the 51 chase drain locations (Tables I and II), about 60 of the 71 lots with drains (about 85 percent) are Type "A" lots and the remaining lots are Type "B", "T" or G" lots. No walkout lots appear to have a chase drain. Although the Type "B", walkout and garden level lots have fewer chase drains, these configurations contribute surface runoff toward lots at their rear and increase the probability for chase drains on the adjoining lots.

Surface Drainage of Adjacent areas

Surface runoff is affected by drainage conditions of the adjacent areas or lots. We have seen instances of excessive surface runoff for lots located at the

base of large slopes, at the lower portion of a block, and behind and below walk-out basement lots. Surface water that seeps into the ground can also cause seepage onto these lots, or into foundation drains. These factors were evaluated and summarized in Tables I and II for the 51 chase drain locations.

The data indicate about 76 percent of the lots with chase drains are located at the base of slopes, about 25 percent are at the lower portion of a block, and about 38 percent are located below and behind walkout basement lots.

Some of the lots have compound effects from adjacent lots. Only two chase drain locations (Lots 60/61 and 150/151) seem to be not affected by adjacent surface drainage conditions.

Landscaping Water Use

Based on our experience, landscaping watering can have a large impact on surface water. We were provided with water use records for most lots (186 of 195 lots) within Filing No. 122-U. The records contain water use by each residence for the year 2005. For purpose of analysis, we assumed that the difference between the winter (November through February) and summer (May through October) use would correspond to the amount of water used outdoors, primarily for irrigation during the lawn growing season.

Watering requirements have been developed by the Denver Water Board to assist homeowners in the Denver Metropolitan area determine the amount of irrigation necessary to maintain a healthy lawn while conserving water[1]. Their guidelines indicate irrigated grass in this area requires about 0.5 to 1.75 inches of water per week during the irrigation period from May through October. The quantity varies through the season.

Based on aerial photographs of the site, we estimated the irrigated area for each lot and calculated the irrigation demand based on the Denver Water guidelines. We compared this value to the 2005 assumed outdoor water use. The resulting outdoor water use evaluation is presented on Fig. 7. Our estimates do not take precipitation into account. On 73 lots (37 percent), less water was used for irrigation than the guidelines suggest. On 113 lots (58 percent), more water was used than necessary to maintain landscaping. In our experience, excess landscaping watering often cannot be readily absorbed by the ground and results in surface water that must be directed away from the residence.

Compound Factors

As part of our analysis, we evaluated the influence of compound factors on the need for chase drains on the site. Specifically, we compiled frequency of chase drains for combinations of those factors where lots had about a 50 percent or higher occurrence of chase drains (Tables II and III). In general, it appeared

[1]Denver Water Board website www.denverwater.org

that those lots with the highest frequency of chase drains were sub-excavated lots that were behind and below garden level or walkout lots, at the base of a slope, or were graded for "A" surface drainage.

CONCLUSIONS

Based on this study and our experience, we believe the source of excess surface water is predominantly from precipitation events and landscaping watering after development, not pre-existing underground springs or seepages. Surface water at the higher portion of the site can infiltrate and seep into the ground surface and become ground water or seepage. This ground water may occur in the basements of the lower lots or emerge on slopes. It is difficult to clearly differentiate whether the water is originating from ground water or surface water.

The study suggests sub-excavation may indirectly contribute to more surface water and the need of chase drains (Tables II and III). This is because the sub-excavation fill generally exhibits comparatively lower permeability than natural surface soils and reduces infiltration. Basement construction may also be a factor, as basement excavations may intercept seepage; water tends to infiltrate to basement level through wall backfill, resulting in more pumping of foundation drains and increased water flow in the swales.

Surface drainage from adjacent lots apparently has a significant effect on the excess surface water on an individual lot. For lots located at the base of the slopes, at the lower portion of a block, and/or behind and below walkout basement lots, there is higher risk of developing excessive surface water and need for chase drains. The data indicates Type "A" lots are more likely to need chase drains than other types of lots.

Based on the analyses of water use, overall, about 57 percent of the 195 lots studied applied excessive water for landscaping watering. For the 71 lots with chase drains, about 40 percent of the lots have applied excessive landscaping watering. This suggests lots upgrade from the chase drain lots contribute to the excessive surface water or seepage to the downgrade lots, or reduce their need to irrigate.

RECOMMENDATIONS

There are measures that can be implemented to reduce excess surface water and control ground water at the basement level. We recommend the following measures be considered at this site and future subdivisions.

1. **Homeowners should be educated about the amount of water necessary to maintain irrigation. Water conservation should be encouraged.**

2. **If allowed by the local Metropolitan District/maintaining entity of the sanitary sewer, we recommend installation of an underdrain**

system below the sewer and connecting the basement foundation drain to the underdrain to reduce pumping of water from the basement level to the ground surface.

3. **For existing subdivisions, installation of trench drains behind curb and sidewalk (such as Douglas County Drawing No. SP37a, Fig. 9) can be considered. When excessive water flows over sidewalks, it is possible to direct surface water in the swales to the trench drain so that water in the swale will not run over sidewalks. We caution against connecting all swales to the trench drains because this may direct water beneath pavements.**

4. **For new subdivisions, installation of trench drain systems will be more economical and easier to implement during development. The merits of installation of a trench drain system should be considered by the builder. Where sub-excavation is planned or for subdivisions with lots concentrated at the base of slopes or below walkout or garden level lots, we believe installation of trench drains during development may be prudent.**

5. **In some instances (such as mitigation of excess surface drainage in an existing subdivision), it may not be possible to install the trench drain behind the sidewalk due to existing landscaping or utilities. In these instances, the trench drain could be considered at the front (streetside) edge of the curb and gutter, with an area drain or sump pit behind the walk at each common swale line. In our opinion, this configuration may not be as effective as the back-of-sidewalk system, as water may still flow over sidewalks before being intercepted by the area drains or sumps. Should this configuration be installed, a non-perforated pipe would be used instead of perforated pipe, and each area drain connected with a stub-out sloping toward the trench drain. As with the back-of-sidewalk drain, care must be taken to avoid directing water beneath pavements.**

6. **Installation of drainage swales and/or interceptor drains at the base of slopes and at the lot line behind walkout lots.**

7. **Improve surface drainage between lots to reduce runoff from upgrade lots to downgrade lots and pay special attention to lots located at the lower portion of a block.**

8. **Improve compaction of the basement backfill to reduce surface water infiltration and backfill settlement. If a higher degree of compaction is used, basement walls should be designed for higher lateral earth pressures. Care must be taken during compaction to avoid overstressing and damaging foundation walls.**

9. For lots where sump pumps discharge frequently, advise homeowners to extend discharge pipes to the swale and be of sufficient length to not discharge to the backfill zone.

10. Advise homeowners to eliminate the use of buried downspouts, where possible. Where buried downspouts will still be used, verify the downspout flow is directed away from the residence.

11. The ground surface on some of the lots appeared to slope towards the residences. Where homeowners report frequent pumping problems, the lot drainage should be verified.

12. Additional test holes can be performed to monitor the current ground water levels. Suggested test hole locations are presented on Fig. 8.

LIMITATIONS

The discussions and recommendations provided in this letter are based upon the data provided, our field observations, and experience with similar projects. We believe this investigation was conducted with that level of skill and care ordinarily used by geotechnical engineers practicing in this area at this time. No warranty, express or implied, is made.

We appreciate this opportunity to serve you. If you have questions, please call.

Very truly yours,

CTL | THOMPSON, INC.

COLORADO REGISTERED PROFESSIONAL ENGINEER
WILLIAM D. RETHAMEL
36508
1/2/08

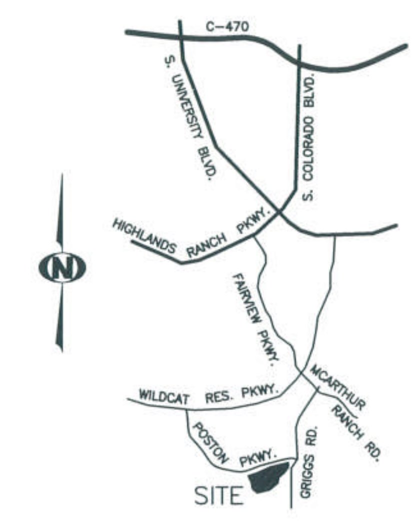
William D. Rethamel, P.E.
Project Engineer

Reviewed by:

Nan-Ping Hsieh, P.E.
Principal

WDR:NPH/wdr/bg/hat
(3 copies)

Attachments



VICINITY MAP
NOT TO SCALE

LEGEND:

1 INDICATES LOT NUMBER

6030 INDICATES GROUND SURFACE ELEVATION BEFORE GRADING (FEET)

6100 INDICATES PROPOSED GROUND SURFACE ELEVATION AFTER GRADING (FEET)

■ INDICATES APPROXIMATE CHASE DRAIN OBSERVED BY CTL/THOMPSON, INC.

NOTE: GRADING CONTOURS PROVIDED BY JR ENGINEERING, LTD.

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Development Plan

Fig. 1

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LEGEND:

1 INDICATES LOT NUMBER

(5) INDICATES DEPTH OF FILL AT BORING LOCATION ON LOT BY CTL|THOMPSON, INC. OR A.G. WASSENAAR, INC.

INDICATES LOT WHERE SUB–EXCAVATION TO A DEPTH OF 16 FEET OR MORE BELOW FINAL GRADE WAS PERFORMED.

INDICATES LOT WHERE 15 FEET OR MORE OF SITE GRADING FILL WAS PLACED BASED ON DRILL HOLE DATA AND SITE GRADING PLANS PREPARED BY JR ENGINEERING, LTD. (THEIR JOB NO. 43464; DATED JULY 7, 2000).

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Depth of Fill

Fig. 2

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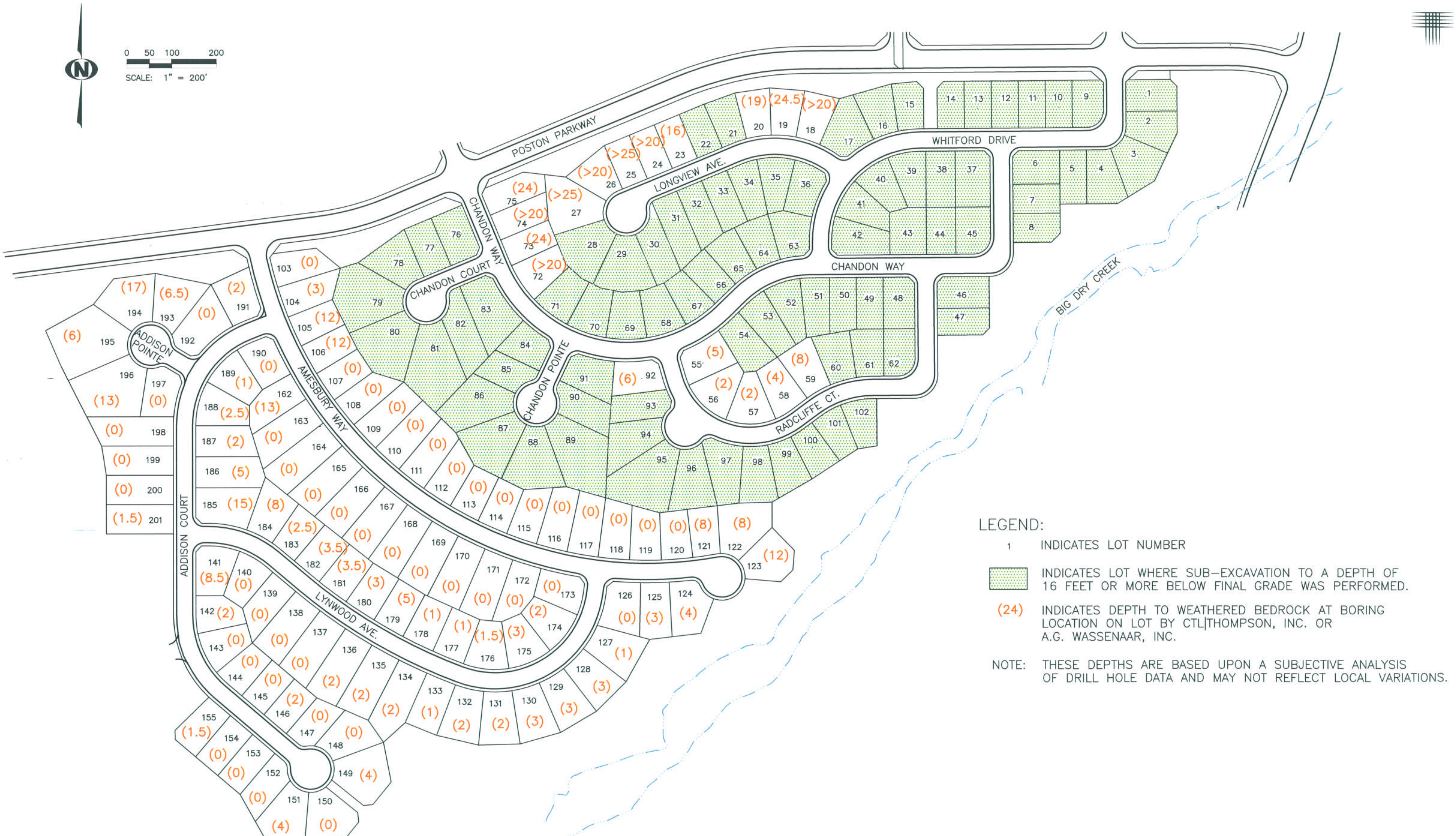

LEGEND:

1 INDICATES LOT NUMBER

INDICATES LOT WHERE SUB-EXCAVATION TO A DEPTH OF 16 FEET OR MORE BELOW FINAL GRADE WAS PERFORMED.

(24) INDICATES DEPTH TO WEATHERED BEDROCK AT BORING LOCATION ON LOT BY CTL|THOMPSON, INC. OR A.G. WASSENAAR, INC.

NOTE: THESE DEPTHS ARE BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS.

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Depth to Bedrock

Fig. 3

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LEGEND:

1 INDICATES LOT NUMBER

INDICATES LOT WHERE SUB-EXCAVATION TO A DEPTH OF 16 FEET OR MORE BELOW FINAL GRADE WAS PERFORMED.

6050 INDICATES ESTIMATED BEDROCK ELEVATION (FEET)

NOTE: THIS ESTIMATE WAS BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS.

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Estimated Bedrock Elevation

Fig. 4

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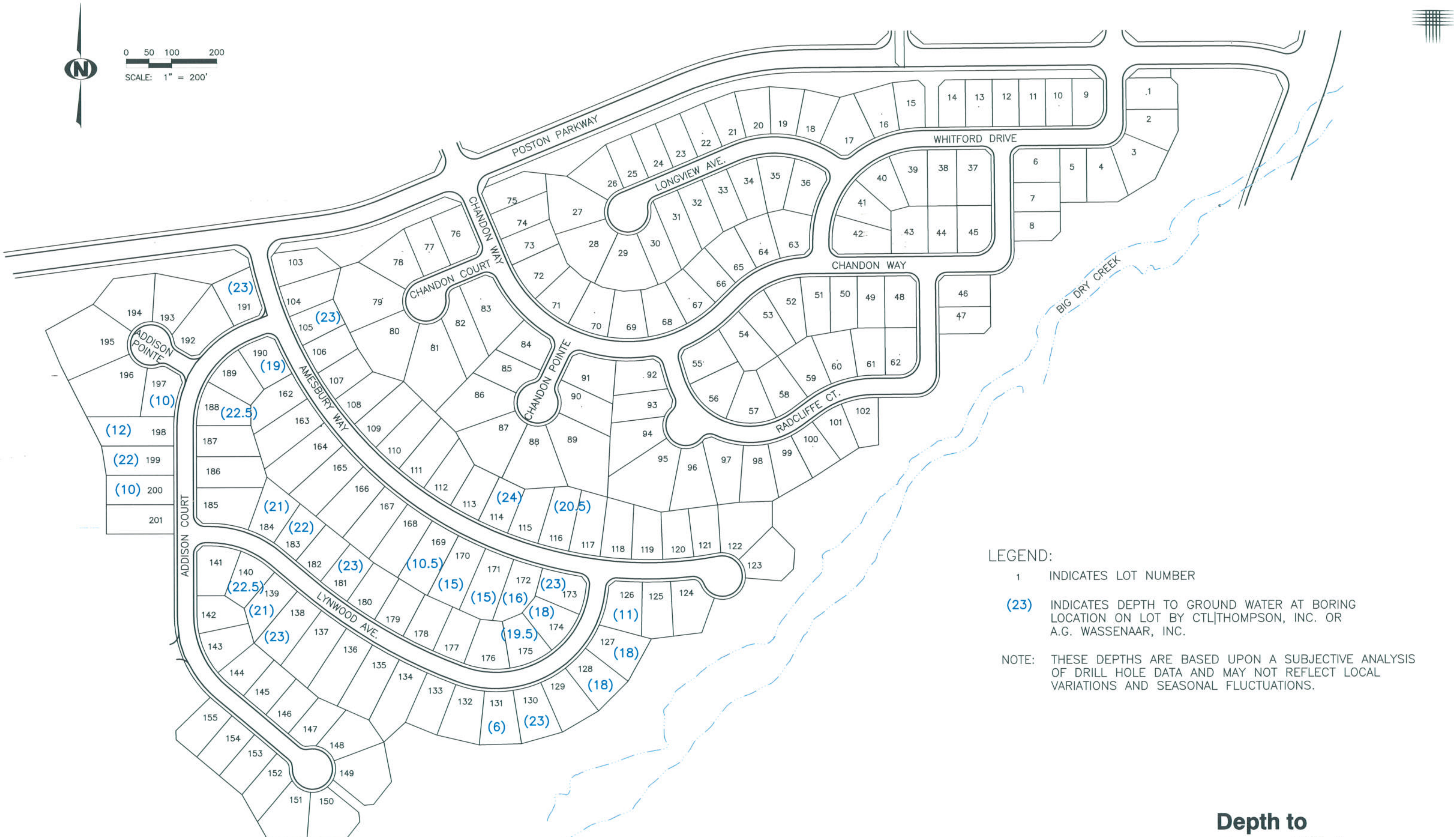


LEGEND:

1 INDICATES LOT NUMBER

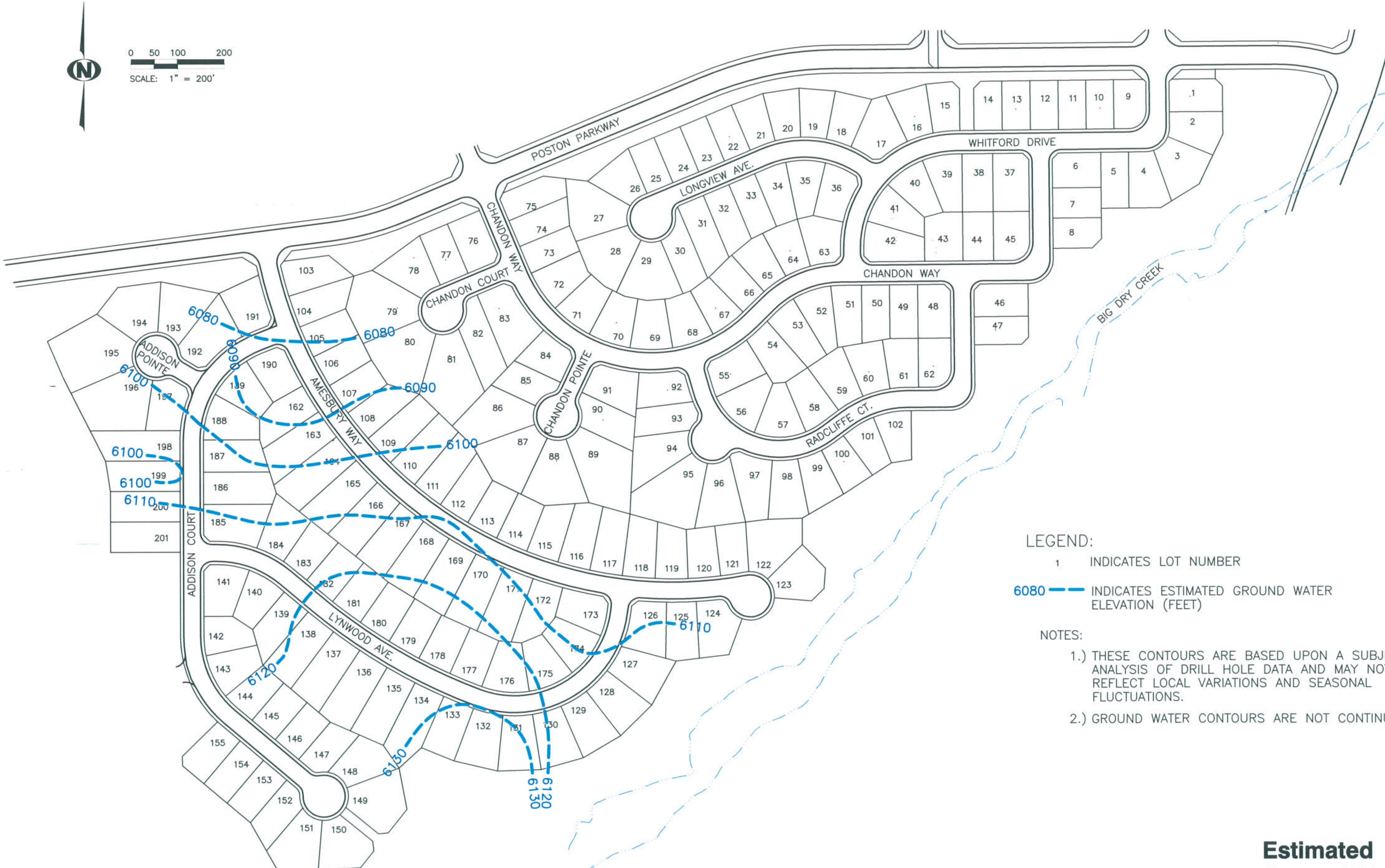
(23) INDICATES DEPTH TO GROUND WATER AT BORING LOCATION ON LOT BY CTL|THOMPSON, INC. OR A.G. WASSENAAR, INC.

NOTE: THESE DEPTHS ARE BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS AND SEASONAL FLUCTUATIONS.

Depth to Ground Water

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Fig. 5



LEGEND:

1 INDICATES LOT NUMBER

6080 — — INDICATES ESTIMATED GROUND WATER ELEVATION (FEET)

NOTES:

1.) THESE CONTOURS ARE BASED UPON A SUBJECTIVE ANALYSIS OF DRILL HOLE DATA AND MAY NOT REFLECT LOCAL VARIATIONS AND SEASONAL FLUCTUATIONS.

2.) GROUND WATER CONTOURS ARE NOT CONTINUOUS.

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Estimated Ground Water Elevation

Fig. 6

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LEGEND:

1 INDICATES LOT NUMBER

6030 INDICATES GROUND SURFACE ELEVATION BEFORE GRADING (FEET)

6100 INDICATES PROPOSED GROUND SURFACE ELEVATION AFTER GRADING (FEET)

INDICATES APPROXIMATE CHASE DRAIN OBSERVED BY CTL/THOMPSON, INC.

NOTE: GRADING CONTOURS PROVIDED BY JR ENGINEERING, LTD.

INDICATES LOT WHERE LANDSCAPE WATERING IS ESTIMATED TO BE GREATER THAN MINIMUM NECESSARY TO SUSTAIN VEGETATION.

INDICATES LOT WHERE LANDSCAPE WATERING IS ESTIMATED TO BE LESS THAN OR EQUAL TO MINIMUM NECESSARY TO SUSTAIN VEGETATION.

INDICATES NO WATER USE DATA AVAILABLE FOR THIS LOT.

NOTE: EVALUATION OF WATER USE WAS BASED ON IRRIGATION GUIDELINES PROVIDED BY DENVER WATER AND 2005 WATER USE DATA PROVIDED BY HIGHLANDS RANCH METRO DISTRICT.

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Outdoor Water Use Evaluation

Fig. 7

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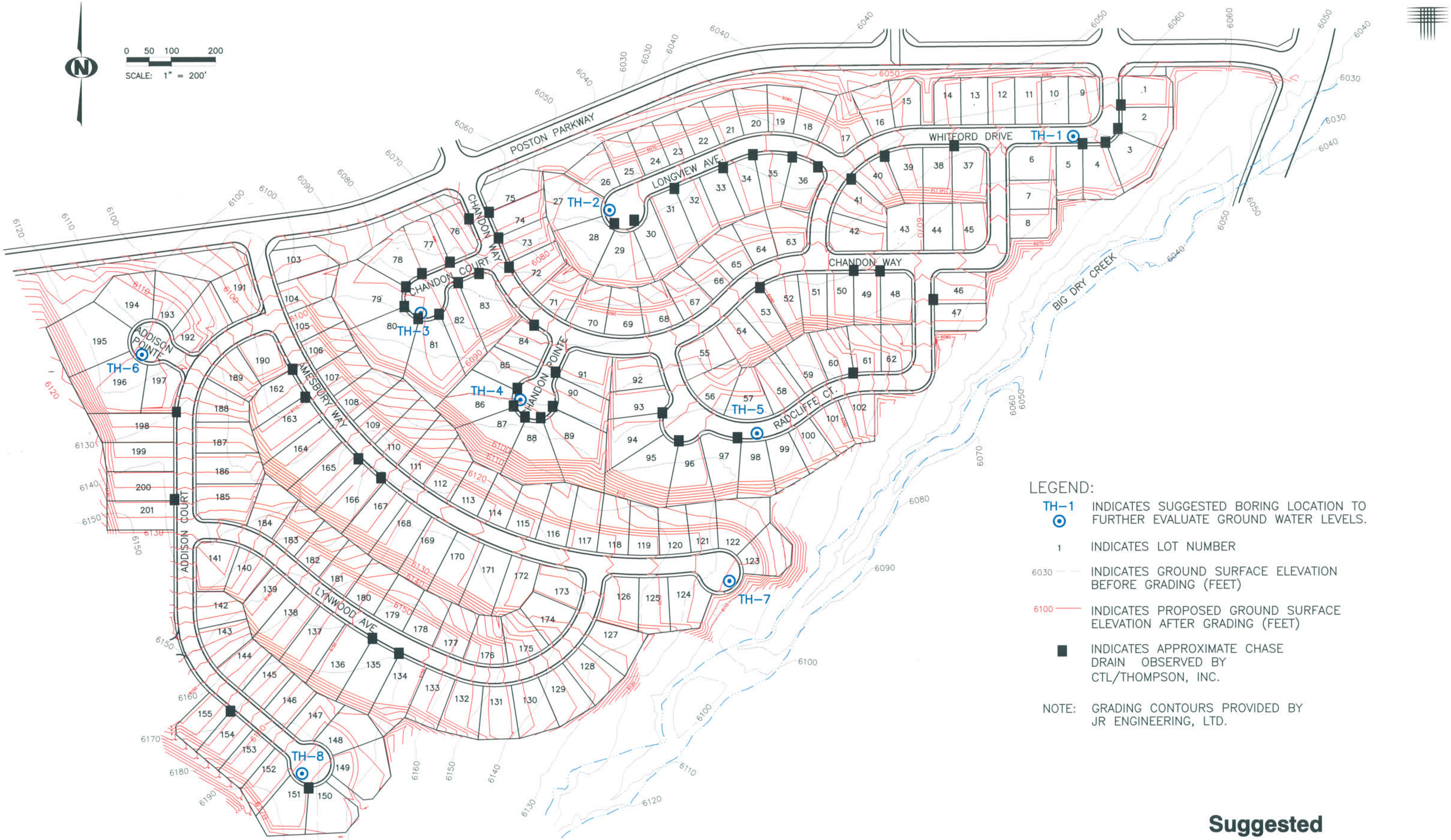

LEGEND:

TH-1 ⊙ INDICATES SUGGESTED BORING LOCATION TO FURTHER EVALUATE GROUND WATER LEVELS.

1 INDICATES LOT NUMBER

6030 INDICATES GROUND SURFACE ELEVATION BEFORE GRADING (FEET)

6100 INDICATES PROPOSED GROUND SURFACE ELEVATION AFTER GRADING (FEET)

■ INDICATES APPROXIMATE CHASE DRAIN OBSERVED BY CTL/THOMPSON, INC.

NOTE: GRADING CONTOURS PROVIDED BY JR ENGINEERING, LTD.

DOUGLAS COUNTY PUBLIC WORKS
HIGHLANDS RANCH, FILING NO. 122-U
Project No. DN42,518-145

Suggested Boring Locations

Fig. 8

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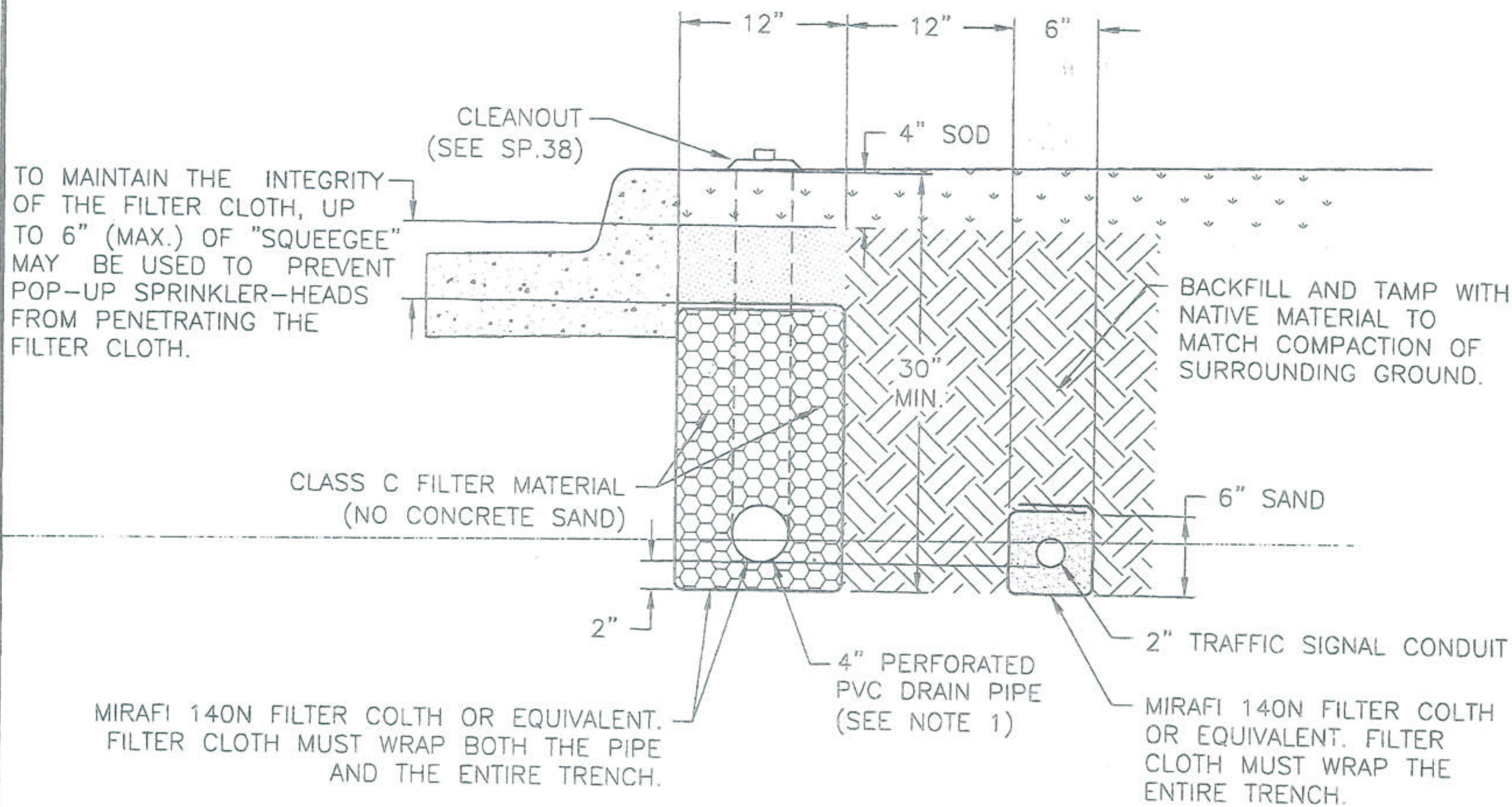

NOTES:

1. THE 4" DRAIN PIPE WILL BE CONNECTED TO A STORM DRAINAGE SYSTEM TO CREATE A POSITIVE DRAINAGE OF RUNOFF.
2. 2" POLY PIPE FOR TRAFFIC SIGNAL INTERCONNECT SHALL BE OF MONOLITHIC CONSTRUCTION (NO JOINTS BETWEEN PULLBOXES).
3. TRENCH DRAIN CLEANOUTS SHALL BE INSTALLED EVERY 200 FEET.
4. TRAFFIC SIGNAL CONSUIT SHALL BE SCHEDULE 80 PVC WITH PULLROPE AND TYPE II PULLBOX EVERY 400 FEET.

TRENCH DRAIN

DOUGLAS COUNTY
DEPARTMENT OF PUBLIC WORKS
Engineering Division

Issued:
Revised:
Drawing No. SP.37a

TABLE I

FACTORS AFFECTING EXCESSIVE SURFACE RUNOFF

(FOR LOTS WITH CHASE DRAIN INSTALLED)

DRAIN (LOT NO.)	GROUND WATER DEPTH BEFORE CONSTRUCTION (FT)	SUB-EXCAVATION OR DEEP FILL	BEDROCK DEPTH (FT)	LOT TYPE	AT THE BASE OF SLOPE	AT LOWER PORTION OF THE BLOCK	BELOW WALK-OUT LOTS	OUTDOOR WATER USE OVERAGE	OVERWATERING LOT(S) UPSLOPE
1/2	DRY	YES	> 16	A	YES	YES	NO	YES	YES
2/3	DRY	YES	> 16	A	YES	YES	NO	YES	YES
3/4	DRY	YES	> 16	A	YES	NO	NO	YES	YES
4/5	DRY	YES	> 16	A	YES	NO	NO	YES	YES
28/29	DRY	YES	> 16	A	YES	NO	YES	NO	NO/YES
29/30	DRY	YES	> 16	A	YES	NO	YES	NO/YES	YES
31/32	DRY	YES	> 16	A	YES	NO	YES	NO/YES	YES/NO
33/34	DRY	YES	> 16	A	YES	NO	YES	NO	YES/NO
34/35	DRY	YES	> 16	A	YES	NO/YES	YES	NO	NO
35/36	DRY	YES	> 16	A	YES	YES	YES	NO/YES	NO/YES
36	DRY	YES	> 16	A	YES	YES	YES	YES	YES
37/38	DRY	YES	> 16	A	YES	NO/YES	NO	YES/NO	NO/YES
39/40	DRY	YES	> 16	A	YES	NO	NO	YES	YES
40/41	DRY	YES	> 16	A/T	YES/NO	NO	NO	YES	YES/NO
46/47	DRY	YES	> 16	A	YES	NO	NO	NO	NO
48/49	DRY	YES	> 16	A	YES	YES	YES	YES/NO	NO
49/50	DRY	YES	> 16	A	YES/NO	YES/NO	YES/NO	NO	NO
52/53	DRY	YES	> 16	A	YES	NO	NO	NO	NO
60/61	DRY	YES	> 16	T/G	NO	NO	NO	NO	NO
72/73	DRY	YES	> 20	T/A	NO	NO	NO	NO	NO
73/74	DRY	YES	> 20	A	NO	NO	NO	NO	NO
74/75	DRY	YES	> 20	A	NO/YES	NO/YES	NO	NA/NO	NO
76	DRY	YES	> 16	B	NO	YES	NO	YES	NO
76/77	DRY	YES	> 16	B	NO	YES	NO	YES/NO	NO/YES
77/78	DRY	YES	> 16	B/T	N	YES/NO	NO	NO/YES	YES/NO
78/79	DRY	YES	> 16	T/A	NO/YES	NO	NO/YES	YES/NO	NO/YES
79/80	DRY	YES	> 16	A	YES	NO	YES	NO	YES
80/81	DRY	YES	> 16	A	YES	NO	YES	NO	YES
81/82	DRY	YES	> 16	A	YES	NO/YES	YES/NO	NO	YES
82/83	DRY	YES	> 16	A	YES	YES	NO	NO	YES
83	DRY	YES	> 16	A	YES	YES	NO	NO	YES
84	DRY	YES	> 16	B	NO	NO	NO	YES	YES
85/86	DRY	YES	> 16	B/T	NO/YES	NO	NO/YES	YES/NO	NO/YES
86/87	DRY	YES	> 16	T/A	YES	NO	YES	NO	YES
87/88	DRY	YES	> 16	A	YES	NO	YES	NO	YES
88/89	DRY	YES	> 16	A	YES	NO	YES	NO	YES
89/90	DRY	YES	> 16	A	YES/NO	NO/YES	YES/NO	NO	YES/NO
90/91	DRY	YES	> 16	A	NO	YES	NO	NO	NO
93/94	DRY	YES	> 16	A	NO	YES/NO	NO	YES	YES/NO
95/96	DRY	YES	> 16	A	YES	NO	YES	NO/YES	YES
97/98	DRY	YES	> 16	A	YES	NO	YES	NO	YES
134/135	DRY	NO	2	A	YES	NO	YES	YES/NO	NO
135/136	DRY	NO	2	A	YES	NO	YES/NO	NO/YES	NO
150/151	DRY	NO	0/4	T/A	NO/YES	NO	NO	YES/NO	NO/YES
154/155	DRY	NO	0/1.5	A	YES	NO/YES	NO	YES	NO/YES
190/162	DRY	NO	13/0	A	YES	YES	NO	YES	NO/YES
162/163	DRY	NO	13/0	A	YES	YES/NO	NO	YES/NO	NO
165/166	DRY	NO	0	A	YES	NO	YES	NA/YES	YES
166/167	DRY	NO	0	A	YES	NO	YES	YES	YES/NO
197/198	10/12	NO	0	A	YES	NO	NO	NA/YES	YES
200/201	10	NO	0/1.5	A	YES	NO	NO	NO	NO

TABLE II

FACTORS AFFECTING EXCESSIVE RUNOFF (FOR ALL LOTS)

FACTOR	LOTS WITH CHASE DRAINS	LOTS WITHOUT CHASE DRAINS	DATA NOT AVAILABLE	TOTAL LOTS
	FREQUENCY AND PERCENT			
"A" LOTS	60 65%	32 35%		92
"B" LOTS	4 15%	23 85%		27
"A/B" LOTS	0 0%	3 100%		3
"T" LOTS	6 40%	9 60%		15
"G" LOTS	1 5%	18 95%		19
"W" LOTS	0 0%	39 100%		39
SUB-EXCAVATED LOTS	50 60%	34 40%		84
NON-SUB-EXCAVATED LOTS	21 19%	90 81%		111
GROUND WATER BELOW LOT AFTER DRILLING	3 2%	19 15%	102 82%	124
LOT AT BASE OF SLOPE	54 68%	26 33%		80
LOT AT LOWER PORTION OF BLOCK	18 47%	20 53%		38
LOT LOCATED BELOW "G" OR "W" LOT	27 68%	13 33%		40
LOT HAS OUTDOOR WATER USE OVERAGE	30 27%	81 73%		111
LOT HAS OVERWATERING LOT(S) UPSLOPE	36 32%	78 68%		114

TABLE III

COMBINED FACTORS AFFECTING EXCESSIVE RUNOFF (FOR LOTS WITH CHASE DRAINS)

FACTOR	LOTS WITH CHASE DRAINS	LOTS WITHOUT CHASE DRAINS	TOTAL LOTS
	FREQUENCY AND PERCENT		
"A" LOT AND AT BASE OF SLOPE	53 69%	24 31%	77
"A" LOT AND SUB-EXCAVATED	41 82%	9 18%	50
"A" LOT AND AT LOWER PORTION OF BLOCK	16 67%	8 33%	24
"A" LOT AND BELOW "G" OR "W" LOT	26 76%	8 24%	34
SUB-EXCAVATED LOT AND AT BASE OF SLOPE	38 86%	6 14%	44
SUB-EXCAVATED LOT AND AT LOWER PORTION OF BLOCK	14 70%	6 30%	20
SUB-EXCAVATED LOT AND BELOW "G" OR "W" LOT	22 96%	1 4%	23
LOT AT BASE OF SLOPE AND LOWER PORTION OF BLOCK	12 75%	4 25%	16
LOT AT BASE OF SLOPE AND BELOW "G" OR "W" LOT	27 75%	19 53%	36
LOT AT LOWER PORTION OF BLOCK AND BELOW "G" OR "W" LOT	4 57%	3 43%	7