Chapter 5. Design Report Requirements

5.1 General

The purpose of this chapter is to provide the requirements for all reports required through the plan review process for new developments or as required in capital project processes. This chapter includes Geotechnical reports, traffic reports, utility reports including sanitary sewer and water, storm drainage report, pavement design, and pavement evaluation.

5.2 Geotechnical Report

Geotechnical report content may vary by project size and producing agency, but all geotechnical reports should contain certain basic information including summary of all subsurface exploration data, interpretation, and analysis of the subsurface, specific engineering recommendations for design, and discussion for solution of anticipated problems. Specifics and details outlined in following chapter.

5.2.1 Basic Report Requirements

A geotechnical report shall be submitted with the preliminary plat in the development process (for any project over 10,000 s.f.) or submitted with preliminary design plans for capital projects. The report shall show results from all required testing in the appendices. The report shall also include a description of site characteristics, e.g., topography, drainage features, etc.

5.2.2 Detailed Report Requirements

In addition to the basic report requirements, each soils report shall include the following items:

List of Required Items:

- Site location and description
- Laboratory test reports with evaluations
    a) Visual classification
    b) Liquid limit - AASHTO T89 or ASTM D4318
    c) Plastic limit - AASHTO T90 or ASTM D4318
    d) In-situ moisture content
    e) Percent passing No. 200 sieve - AASHTO T11 or ASTM C117-90
    f) Gradation of granular (sand & gravel) materials - AASHTO T27, ASTM D422 or ASTM C136
    g) AASHTO classification and group index - AASHTO M145
    h) Standard Penetrations Test
    i) Swell Evaluation
- Boring logs.

- Soil and groundwater conditions. The expected seasonal elevation variation shall be summarized.
- Depth to bedrock. To indicate shallow bedrock. Include mitigation requirements if bedrock is within three feet.
- (3') of subgrade.
- Percentage of soluble sulfates.
- Mitigation plans.
- Elevation of groundwater encountered in each boring.
- Additional tests. These may be required for trench backfill evaluation, fill evaluation, etc.
- Recommendations and discussions.
- Engineer seal and signature. Required.

5.2.3 Soil Borings for Geotechnical Report

Timing of Soil Borings

- **Initial Borings.** The information from the initial soil borings must be summarized in the geotechnical report. The entire site shall be sampled for initial testing. This is required because street locations may be determined at this stage or may change.
- **Structures.** Soil borings for design of structures shall be taken prior to the design of the structure.
- **Imported Fill for Right-of-Way Grading.** All fill material shall be tested by the Contractor and approved by the City prior to its use on the project. The material should meet minimum requirements and be better than or equal to existing conditions. No material shall be imported which has a liquid limit greater than 40 and plasticity index greater than 20, unless otherwise approved by the City.

5.2.4 Frequency of Soil Borings

Basic Requirements

A minimum of two (2) borings shall be provided for each project. The number of borings should be dependent on project size and geotechnical Engineer's recommendations. The Engineering Division may require more frequent testing.

Structures

Testing frequency for structures shall satisfy AASHTO Bridge Design requirements and CDOT Materials Testing requirements.

5.2.5 Soil Boring Depth

Basic Requirements

Samples shall be taken to a minimum depth of 10 feet below the finished grades. Use standard care in determining the number of samples that are needed to characterize soils.

Groundwater or Bedrock

Borings shall extend deeper if needed to determine if bedrock or high groundwater levels are design concerns. Minimum depth to bedrock shall be three (3) feet below the finished subgrade surface.

Structures

Samples for structures shall be taken to a minimum depth of 10 feet below the footing elevation. Additional depth may be required for piers or piles.

5.2.6 Soil Testing

Required Tests

The tests marked with an "X" are required for the subgrade soils investigations or final pavement design testing. Refer to ***Chapter 11- Roadways & Pavements***.

Classification Testing

Soils shall be classified visually and tested to determine the properties. Sands and gravel samples shall be analyzed for gradation where needed to comply with classification requirements.

Subgrade Support Testing

Individual subgrade or composite samples shall be tested for subgrade support value. The geotechnical report shall clearly state whether or not the subgrade soil is capable of supporting the proposed construction and design traffic loads. The top one foot (1') of subgrade shall have an R-value of 20 or greater. Recommendation for subgrade stabilization, if required, shall also be provided. The final pavement report shall contain specific mitigation. Refer to other sections of this chapter for requirements.

Right-of-Way Fill Material Testing

- **Test Prior to Use.** All imported fill material shall be evaluated for swell and R-value and approved by the Engineering Division prior to use in the Right-of-Way.
- **R-value and Plasticity Index.** All imported fill shall have an R-value and plasticity index better than or equal to the subgrade material within the Right-of-Way. Refer to 5.2.1.
- **Expansion Potential.** Imported fill shall not have a liquid limit greater than 40 and plasticity index greater than 20.

Table 5.1: Required Test

Test	Geotechnical Report	Final Pavement Design Report
Visual	X	X
Liquid Limit	X	X
Plastic Limit	X	X
Moisture	X	X

Percent Passing 200	X	X
Gradation (Granular Soils)	X	X
AASHTO Classification	X	X
Subgrade Support	X	
R-Value	X	
Swell Evaluation (Preliminary Considerations)	Indicator: Low/Moderate/High for Moderate or High, Run Swell Tests	Mitigation and Detailed Analysis
Percentage of Soluble Sulfates	X	X
Standard Penetration Test	X	X
Groundwater	X	X
Bedrock Level	X	X
Corrosion Potential Resistivity	X	
Soluble Sulfate	X	X

5.2.7 Soil Grouping

General

To simplify subgrade support testing, soil samples may be combined to form soil groups consistent with the AASHTO classification, group index, and location for the area investigated. Groupings shall not mix samples with different AASHTO classifications. (For example, soils with swell potential greater than two (2) percent may not be grouped).

Composite Samples

Composite samples may be obtained by mixing portions of each sample within a soil group to provide a uniform sample of the soil group. The composite samples shall be representative of the worst-case subgrade soils for the project site unless separate designs are proposed for distinct soil groups and sufficient field sampling is conducted to determine the special limits of each soil unit identified. Composite samples used for Hveem, subgrade strength testing (R-values) shall not be improved in R-value strength by mixing soils with a higher sand content with material of less strength. Appropriateness of the composite sample shall be evaluated through the comparison of soil gradation and Atterberg limits and soil gradations for the site soils as compared with the subject composite sample.

Specific Tests for Composite Samples

Composite samples shall be classified using the methods described in above. Composite samples remolded in the laboratory shall not be used for swell/consolidation testing.

Soluble Sulfate Test

A minimum of one (1) soluble sulfate test shall be run on each composite sample.

5.2.8 Subsurface Water Investigation

Criteria

If groundwater or bedrock is encountered or predicted to be encountered within five (5) feet of the original or proposed ground surface, a subsurface water investigation report shall be submitted for acceptance by the Engineering Division. This report is required to ensure mitigation of high groundwater effects upon public improvements within the Right-of-Way. This information may be a separate report or may be included in the geotechnical report.

Waiver

A subsurface water investigation may be waived if the Applicant and Designer certify that the street subgrade elevations will be a minimum of three (3) feet above the "maximum" predicted (seasonal highest) water table.

Exception

A subsurface water investigation is not required for temporary dewatering activity needed to facilitate construction of buried utilities. However, all applicable state requirements must be followed.

Report Requirements

The subsurface water investigation report shall include the following information.

List of Required Information

- Site location and description. Include locations of any irrigation ditches and wetlands.
- Elevation of water table, direction of flow, flow rates, groundwater barriers, and seasonal high-water level.
- Potential sources of groundwater. Include proximity to irrigation ditch systems.
- Water rights.
- Other relevant subsurface information such as water ownership (water rights), groundwater quality (contamination or other undesirable characteristics).
- Potential future groundwater conditions.
- Subsurface drainage recommendations, including its effects on all conditions, including sensitive habitat.
- Cone of influence.
- Control measures and designs.

    1. **Subsurface Drains.** If subsurface drains are recommended, the drains must have a gravity discharge without any possibility of back flow or blockage of the outlet. Any subsurface drain system shall be

owned and maintained by the Contractor or the Contractor's assigned successor(s). These drains may discharge into the City's storm drainage system, including inlets or detention ponds, upon approval of the Public Works Director. The underdrains may not drain to the gutter/flowline of public streets. Anticipated impacts to the groundwater table on adjacent properties must be quantified. The plat and construction plans shall clearly state that the City / County has no maintenance responsibility for this utility and any damage caused by said maintenance shall be repaired by the entity in charge of maintenance to preexisting conditions or better.

2. **Drain Lines.** The drain lines may be installed in the sanitary sewer trench, at an elevation of one sewer diameter lower than the sanitary sewer line, except in Loveland (city limits only). Flexible pipe will not be accepted.

3. **Drain Line Separation from Sewer.** The drain line shall be marked to specifically distinguish the drain from the sanitary sewer line.

4. **Pipe.** The drain line shall be an approved material pipe, for long-term 100 years minimum design life, with appropriate cleanouts.

5. **Drain Outlet.** The outlet of the drain into an inlet structure or detention pond shall be designed to prevent any possibility of backflow and blockage of the drain line.

6. Professional Engineer's seal and signature.

5.2.9 Soil Mitigation

Mitigation Plans

All problems found in soils investigation (e.g., expansion, frost, soluble sulfates, shallow bedrock, heave, groundwater, soil instability, utility backfill, etc.) shall be addressed in the mitigation plans. All mitigation procedures must be approved by the Engineering Division prior to their implementation.

Mitigation for Swell

If the swell of any subgrade soils is two (2) percent or greater, the pavement design report must provide mitigation measures. Soil swell testing shall be conducted with soil samples that have an initial moisture content equal to or less than four (4) points below optimum moisture. The mitigation measures shall reduce destructive swell potential to an acceptable level of less than two (2) percent at 150 pounds per square foot surcharge. The swell test report shall specify sample conditions, surcharge pressures, and other key testing factors.

Methods of Mitigation

Possible measures for mitigation may include the following:

- **Over-Excavation.** Over-excavation and replacement with suitable non-expansive or low-expansive material to a depth sufficient to mitigate expansion is a common mitigation method.

- **Chemical Treatment.** Chemical treatment may be used to mitigate soil condition. The addition of lime, fly ash, or cement treatment shall follow an approved mix design process. Additional testing is required to verify no swell is introduced during chemical treatment.

- **Subdrains.** Subdrains may be effective at reducing the groundwater, thereby reducing swelling. However, subdrains will be subject to all of the subsurface drain requirements in these STANDARDS AND SPECIFICATIONS.

- **Moisture Treatments.** Condition with moisture and compact to an appropriate level of compaction for the expansive condition, including stability requirements. The geotechnical engineer shall specify the target moisture content based on laboratory testing. Moisture content of the prepared subgrade soils shall be tested within 24-hours prior to paving. If unstable paving conditions due to over moistened soils appear, the contractor shall cease paving and the geotechnical engineer shall develop other forms of mitigation. Moisture treatment alone may not be sufficient. If soil problem mitigation is made, the soil treatment shall extend to the back of curb, or to the back of walk for attached or monolithic walk. For detached walk, separate mitigation procedures may be required.

- **Other Procedures.** Other procedures may be proposed for review and approval by the Engineering Division. The chosen method must work for the full life expectancy of the project.

5.3 Drainage Report

The storm drainage system shall be designed by a professional engineer registered in the State of Colorado utilizing the most current technical standards along with good, sound engineering judgment throughout the design process. The design process includes the submittal of a drainage report consistent with the requirements and recommendations in the Mile High Flood District Drainage Criteria Manual, Volumes 1 through 3 and construction drawings for review and acceptance by the City. The following note shall be incorporated into the drainage report:

"We acknowledge that the City of Northglenn's review of this study is only for general conformance with submittal requirements, current design criteria and standard engineering principles and practices."

This drainage report on new development of (greater than a half an acre) shall be submitted through Planning.

If a drainage report is over twelve months old before it is implemented, the Engineering Division will have to re-certify existing drainage report.

5.3.1 Preliminary Drainage Report/Letter

The purpose of the Preliminary Drainage Report is to identify problems and propose solutions to convey storm drainage through any proposed construction. The effects of off-site drainage areas on the development and the effects of the development on downstream properties must be thoroughly assessed. The Preliminary Drainage Report shall address the entire property boundary for new plats or site plans, whichever is greater.

A Preliminary Drainage Letter will only be allowed with prior approval and must be for projects within areas that have a previously approved drainage plan. It will usually be for pad sites within previously approved commercial sites or for minor changes to existing properties.

All applicable applications for a Right-of-Way Permit, Building Permit, or a Grading Permit shall include information related to stormwater runoff and water quality. The specific requirements vary by type and size of the proposed construction. All applications will include a Preliminary Drainage Plan and Report or letter to document the drainage, water quality and floodplain impacts of the proposed improvements as follows:

- Submit one (1) report and plan sheet to the Public Works Engineering Division for review. This submittal will be in paper report form and electronic form. Engineering personnel will sign the Development Application Form for a plat or site plan when requested, provided the report has been received, the report/letter review fee paid and a copy of the plat or site plan accompanies the Development Application. Contact Public Works for the fee amount.

- The report/letter will be reviewed by Engineering and will be returned to the consultant with comments. The consultant or local representative will be notified by phone or email when the submittal is ready to be picked up.

- The consultant will make necessary revisions and resubmit according to the instructions provided with the report/letter review comments. Each resubmittal must include all previously reviewed reports/letters with prints. Incomplete submittals or non-responsive resubmittals may be rejected and returned without review.

- When indicated by the City of Northglenn, the consultant will submit a finalized report/letter drainage plan for signatures. The approved copy will remain on file in the Engineering Division.

- The review and revisions cycle normally corresponds closely to the Planning Department schedule for plat and other site plan review.

5.3.2 Final Drainage Report

The Final Drainage Report shall be a detailed study and analysis of the proposed development. It shall include calculations for all runoff and for all drainage structures or facilities within the project site. Final drainage reports must be prepared by a qualified Professional Engineer licensed in the State of Colorado, or under their direct supervision, whose seal and signature shall be affixed to the report and all plan sheets.

The Final Drainage Report must be submitted with civil construction plans for water, sewer, streets, and grading as a complete package. The submittal can be made during the processing of planning documents or prior, if desired. Acceptance of the civil plan package is required prior to approval of building permits for development projects. The procedure is as follows:

- Request a pre-submittal meeting with the Public Works Engineering Division. The submittal package, including the final drainage study and plan, will have an initial review for completeness of the submittal. After this meeting the plans will either be returned for additional information or be allowed to be submitted. All meetings with prospective developers are designated as a Planning Division activity.

- Submit one (1) set of civil construction plans (or, the number of sets requested in the pre-submittal meeting), the Final Drainage Reports and the civil plans review fee to the Engineering Division to be logged in for review. The plans will be routed to other departments as necessary. If necessary, plans will be routed to Urban Drainage and Flood Control District or other applicable agencies for review to ensure compliance with their criteria. Contact the Public Works Engineering Division for fee amounts.

- The civil construction plan package will be returned to the consultant with comments and requested revisions.

- The consultant will make necessary revisions and resubmit according to the instructions provided with the City of Northglenn comments. Each resubmittal must include all previously reviewed prints/reports.

- The consultant will submit a clean report and all construction plans for signatures. The approved copies will remain on file in the Engineering Division. Approval of the Final Drainage Report and Civil Construction Plans by all departments is required for Engineering Division approval of building permits.

- The review and its revision cycle are based on the Development Review Process for the City of Northglenn. Quality plans meeting all City of Northglenn standards and criteria will save time for all involved. If the civil plans and drainage report cannot be approved with the third submittal, the review of the plans will start over and a new review fee will be required.

5.3.3 Drainage Report Requirements

General

All reports shall be typed on 8 ½-inch x 11-inch paper and properly bound with durable covers. The cover shall include the full subdivision plat name, the Owner's name, address, phone number, point of contact, the Designer's name, address, phone number, point of contact and approval block. Supporting calculations, charts, and design aids shall be included in the appendix of the report. Plan sheets shall be included in a pocket at the back of the report. The reports shall also be submitted electronically.

5.3.4 Report Format & Required Information

Appendices 5.1 – 5.4 are detailed lists of the required information for Preliminary Drainage Reports and Letters, and for Final Drainage Reports.

5.4 Utility Study – Sanitary Sewer & Water

The following note shall be incorporated into the utility study:

"We acknowledge that the City of Northglenn's review of this study is only for general conformance with submittal requirements, current design criteria and standard engineering principles and practices."

5.4.1 Sanitary Sewer System Study

- The study shall include, as a minimum, the following information and shall be typed and bound in an 8 ½-inch x 11-inch report binder:
- Text, which addresses, a minimum of project location and description, project concept, discussion of any information that would affect the City's ability to serve the new area, and any recommendations and conclusions of the analysis.
- The area, in acres, which could be served by gravity by the new sewer, shown on a topographic map which delineates the basin boundaries.
- The estimated population densities and total population based on land use projections to be served by the new sewer.
- The estimated quantity and quality of any industrial wastes to be discharged to the system.
- Design flow rates, minimum and maximum flow velocities, minimum and maximum pipe slopes, and infiltration allowances.
- The impact of the additional flows on the existing sanitary sewer system at all critical points between the proposed site and the major interceptor.
- A utility map which includes, a minimum of, the following information:
    1. Location of all proposed and existing easements and/or Right of Ways.
    2. Existing and proposed sanitary sewer lines and appurtenances with sizes and slopes shown.
    3. Basin delineation.
    4. All other existing and proposed utilities.

All other requirements for the CDPHE approval when applicable.

5.4.2 General – Water Report

The water system shall be designed by a professional engineer registered in the State of Colorado utilizing the most current technical standards along with good, sound engineering judgment throughout the design process. The design process includes the submittal of a utility study and construction drawings for review and approval by the City. The following note shall be incorporated into the utility study:

"We acknowledge that the City of Northglenn's review of this study is only for general conformance with submittal requirements, current design criteria and standard engineering principles and practices."

Water Study

The Study shall include the following information and shall be bound in an 8 ½-inch x 11-inch report binder:

- Text, which addresses, a minimum of, project location and description, project concept, discussion of any information that would affect the City's ability to serve the new area and any recommendations and conclusions of the analysis.
- The area which could be served by the new water line and any pressure zones, shown on a topographic map which delineates these pressure zones. The pressure zones shall be in conformance with the "Northglenn Treated Water System Modeling Evaluation", latest edition.
- The estimated population densities and total population, based on land use projections, to be served by the new water line.
- Design flow rates, minimum and maximum system residual pressures and head loss in the distribution main.
- A utility map which includes, a minimum of, the following information:
    1. Location of all proposed and existing easements and/or rights of way.
    2. Existing and proposed water lines and appurtenances with sizes, flows, node pressures and demands shown.
    3. Existing pressure zones.
    4. All other existing and proposed utilities.

5.5 Responsibilities for Traffic Studies

Traffic studies may be required by the City to adequately assess the impacts of a development proposal on the existing and/or planned street system. The primary responsibility for assessing the traffic impacts associated with a proposed development shall rest with the Developer, with the City serving in a review capacity. The assessment of these impacts shall be contained with a Traffic Impact Study report as specified in this chapter.

5.5.1 Traffic Impact Letter

For projects generating under 100 new vehicle trips, a Traffic Letter will be accepted to review the traffic impacts. The letter shall provide the City with the knowledge that the new development shall have limited impacts to the adjacent streets.

5.5.2 Full Traffic Impact Report

A written traffic impact study meeting the criteria contained in this chapter shall be required for a development proposal or a capital project improvement project when trip generation during the AM or PM peak hour is expected to exceed 100 vehicles, as determined by the City. This study shall be the responsibility of the applicant and shall be prepared by a Professional Engineer registered in the State of Colorado, with adequate experience in transportation engineering. Upon submission of a draft traffic study, the Engineering Division will review the study data sources, methods, and findings. Comments shall be provided in a written form. The Developer and the project engineer will then have an opportunity to incorporate necessary revisions prior to submitting a final report. All studies shall be accepted by the Engineering Division. The following submittals may require traffic studies:

- A rezoning application or an application for annexation into the City.
- A preliminary map or final plat if the property has already been rezoned for the proposed use and no traffic study was required for the rezoning, or the land use assumptions at the time of platting will result in trip generation increasing by more than 15 percent compared to trip generation estimates made for the traffic study at the time of rezoning.
- Prior to issuance of a building permit, if the property has already been zoned/platted and no previous traffic study less than two (2) years old exists.
- The applicant shall be required to submit a new traffic study if, after submitting the original traffic study for any of the above submittals, the trip generation is increased by more than 15 percent or the land use is changed so that trip generation is increased by more than 15 percent.

All previous traffic studies relating to the development that are more than two (2) years old shall be updated, unless the Engineering Division determines that conditions have not changed significantly. Where access points are not defined or a site plan is not available at the time the traffic study is prepared, additional traffic analysis may be required when a site plan becomes available or the access points are defined.

The applicant will be notified at the pre-planning stage if a traffic study will be required, provided sufficient information is available for the City to determine whether the trip generation criterion has been met. If insufficient information is available but the property appears to involve a sufficiently intense land use, the applicant will be informed that a traffic study is required.

Transportation consultants are required to discuss projects with the Engineering Division prior to starting the study. As a minimum, topics for possible discussion at such meeting shall include trip generation, directional distribution of traffic, trip assignment, definition of the study area, intersections requiring capacity/level of service analysis and methods for projecting build-out volume. This will provide a firm base of cooperation and communication between the City, the owner or developer, and the project's consultants in forecasting future traffic characteristics which realistically define traffic movement associated with the proposed development. Specific requirements will vary depending on the site location.

5.5.3 Types of Improvements Evaluated in Traffic Impact Studies

Vehicular Traffic Improvements

Types of capacity and safety improvements for vehicular traffic include road widening, turn lanes, acceleration and deceleration lanes, intersection through lanes, traffic signals, stop signs, design speed adjustments, and modifications to access points.

Pedestrian Traffic Considerations & Improvements

Pedestrian traffic segment includes review of narrow roadway, short blocks, low traffic speeds, tree-lined sidewalks, well defined crosswalks, median refugees, channelized islands, and underpasses or overhead structures.

Bicycle Traffic Improvements

The addition of on-street bicycle lanes or off-street bicycle paths may be needed to achieve connectivity between the proposed project and the existing bikeway system.

Transit Traffic Improvements

Transit improvements includes accommodation of public transit facilities such as buses, bus stops, bus bays, stations and transit stop facilities.

5.5.4 Traffic Study Format

In order to provide consistency and to facilitate staff review of traffic studies, the following format shall be followed in the preparation of such studies by transportation consultants.

Introduction

The introduction portion of the report must contain the following:

- A note stating the following: “We acknowledge that the City of Northglenn’s review of this study is only for general conformance with submittal requirements, current design criteria, and standard engineering principles and practices."

- A brief description of the size of the land parcel, general terrain features, the location within the jurisdiction and the region shall be included in this section. In addition, the roadways that afford access to the site and are included in the study area shall be identified. The exact limits of the study area should be based on engineering judgment and an understanding of existing traffic conditions surrounding the site. In all instances, however, the study area limits shall be mutually agreed upon by the developer, his engineer and the Engineering Division. A vicinity map that shows the site and the study area boundaries in relation to the surrounding transportation system shall be included.

- The existing and proposed uses of the site shall be identified in terms of the various zoning categories of the City. In addition, the specific use for which the request is being made shall be identified, if known, since a number of uses may be permitted under the existing ordinances. It shall be the intent of the traffic study to evaluate the worst-case traffic impacts for the proposed development allowed by the zoning. If several different uses are permitted by the zoning, the highest trip generation shall be assumed for the study.

- A complete description (including a map) of the existing land uses in the study area, as well as their current zoning and use, shall be included. In addition, all vacant land within the study area and its assumed future uses shall be identified. This latter item is especially important where large tracts of undeveloped land are in the vicinity of the site and within the prescribed study area. Generally, much of this information can be obtained from the City’s Planning Division staff.

- Within the study area, the applicant shall describe and provide volumes for existing roadways and intersections, including geometrics and traffic signal control, as well as improvements contemplated by all affected government agencies. This would include the nature of the improvement project, its extent, implementation schedule, and the agency or funding source responsible. A map shall be provided showing the location of such facilities.

Trip Generation & Design Hour Volumes

A summary table listing each type of land use, the size involved, the average trip generation rates used (total daily traffic and a.m./p.m. peaks) and the resultant total trips generated shall be provided. Trip generation shall be calculated for the maximum uses allowed under the existing and proposed zoning based on the latest data contained within the Institute of Transportation Engineers (ITE) Trip Generation Manual, or other applicable sources. If data is not available for the proposed land use, the City must approve estimated rates prior to acceptance. The calculation of design hour volumes used to determine study area impacts shall be based on:

- Peak hour trip generation rates as published in the ITE Trip Generation Summary or other applicable sources.
- Traffic volume counts for similar existing uses if no published rates are available.
- Additional sources from other jurisdictions, if acceptable to the Engineering Division.
- Use of reduction factors to account for passerby traffic may be considered upon approval of the Engineering Division. Internal trip reductions and modal split assumptions will require analytical support to demonstrate how the figures were derived and will require approval by the Engineering Division.

Trip Distribution

The estimates of percentage distribution of trips from the proposed development to destinations in the metro region shall be clearly stated in the report using the north, south, east and west compass points. Market studies and information concerning origin of trip attractions to the proposed development may be used to support these assumptions where available. A map showing the percentage of site traffic on each street shall be provided as part of the traffic study graphic material.

Trip Assignment

The direction of approach of site-generated traffic via the area's street system shall be presented in this section. The technical analysis steps, basic methods and assumptions used in this work shall be clearly stated and agreed to by the Engineering Division. The assumed trip distribution and assignment shall represent the most logically traveled routes for drivers accessing the proposed development. These routes can be determined by observation of travel patterns to existing land uses in the study area.

Existing & Project Traffic Volumes

Graphics shall be provided which show the following traffic impacts for private access points, public intersections, and public streets:

- A.M. peak-hour site traffic (in and out), including turning movements.
- P.M. peak-hour site traffic (in and out), including turning movements.
- A.M. peak-hour total traffic (in and out), including site-generated traffic. These volumes must include through and turning movement volumes for current conditions and separate set of numbers that also include 20-year projections or build-out, whichever is specified by the Engineering Division.
- P.M. peak-hour total traffic (in and out), including site-generated traffic. These volumes shall include through and turning movement volumes for current conditions and a separate set of numbers that also include 20-year projections or build-out, whichever is specified by the Engineering Division.

- Any other peak hour which may be critical to site traffic and the street system in the study area should be included in the graphics and show the same information as is provided for the A.M./P.M. peak hours.

- Actual counts of existing total daily traffic for the street system in the study area at the time the study is being prepared.

- Projected total daily traffic for the street system in the study area based on traffic from the proposed development and counts of existing daily traffic. The component of the existing daily traffic attributable to the existing uses shall be identified and the increase in total daily traffic from the proposed uses.

- Projected total daily traffic for the street system in the study area based on traffic from the proposed development, counts of existing daily traffic, traffic projections based on build-out of land use within the study area, or a 20-year projection, whichever is specified by the Engineering Division.

All raw traffic count data, including average daily volumes and peak-hour turning movements and analysis worksheets shall be provided in the appendices of the report. Computer techniques and the associated printouts may be used as part of the report. Volume projections for background traffic growth will be provided by the Engineering Division or alternatively, a method for determining these volumes will be recommended by the Engineering Division. All total daily traffic counts shall be actual machine counts and not based on factored peak-hour sampling. Latest available machine counts from the Colorado Department of Transportation, the City and other agencies may be acceptable if not more than two (2) years old.

Level of Service

Level of Service "C" shall be the design objective for all movements, and under no circumstances will less than Level of Service “D" be accepted for site and non-site traffic, including existing traffic at build-out of the study area. The design year will be approximately 20 years following construction and include volumes generated by build-out of the study area or a 20-year projection in background traffic, whichever is specified by the Engineering Division. The following interpretations of "Level of Service" have been provided:

- **Level of Service A.** A condition of free flow with low-traffic density where no vehicle waits longer than one (1) signal cycle.

- **Level of Service B.** A stable flow of traffic where only on a rare occasion do drivers wait through more than one (1) signal cycle.

- **Level of Service C.** Still in the zone of stable flow but intermittently, drivers must wait through more than one (1) signal cycle and back-ups may develop behind left-turning vehicles.

- **Level of Service D.** Approaching instability, drivers are restricted in their freedom to change lanes and delays for approaching vehicles may be substantial during peak hours.

- **Level of Service E.** Traffic volumes are near or at the capacity of the arterial and long queues of vehicles may create lengthy delays, especially for left-turning vehicles.

- **Level of Service F.** Congested condition of forced traffic flow where queued back-ups from locations downstream restrict or prevent movement of vehicles out of the approach creating a storage area during part or all of the peak hour.

Capacity Analysis

A capacity analysis shall be conducted for all public street intersections impacted by the proposed development and for all private property access points to streets adjacent to the proposed development and within the limits of the previously defined study area. The a.m., p.m., and any other possible peak period shall be tested to determine which peak hours need to be analyzed. Capacity calculations should also include an analysis for the 20-year projections or study area build- out conditions. The capacity analysis calculations should be based on the latest approved techniques as published in the latest update of TRB Special Report 209. All capacity analysis worksheets shall be included in the appendices of the report.

Traffic Signals

The need for new traffic signals shall be based on warrants contained in the Manual on Uniform Traffic Control Devices and any additional warrants established by the National Committee on Uniform Traffic Control Devices. In determining the location of a new signal, traffic progression is important. Generally, a spacing of one-half (1/2) mile for all signalized intersections should be maintained. This spacing is desirable to achieve good speed, capacity, and optimum signal progression. Pedestrian movements shall be considered in the evaluation and adequate pedestrian clearance provided in the signal cycle split assumptions.

To provide flexibility for existing conditions and ensure optimum two-way signal progression, an approved traffic engineering analysis shall be made to properly locate all proposed accesses that may require signalization. The section of roadway to be analyzed for signal progression will be determined by the City and will include all existing and possible future signalized intersections.

The progression pattern calculations shall use a cycle consistent with current signal-timing policies of the City. A desirable band width of 50 percent of the signal cycle shall be used where existing conditions allow. Where intersections have no signals presently but are expected to have signals, typically a 60 percent mainline, 40 percent cross-street cycle split should be assumed. Cycle split assumptions shall relate to volume assumptions in the capacity analysis of individual intersections, and where computerized progression analysis techniques are used, they shall be the type which utilize turning-movement volume data and pedestrian clearance times in the development of time/space diagrams. The green time allocated to the cross street shall be considered no less than the time which is required for a pedestrian to clear the main street using the Manual on Uniform Traffic Control Devices standards. Those intersections which would reduce the optimum band width if a traffic signal were installed may be required by the City to remain unsignalized and have turning movements limited by access design or median islands.

Traffic Calming & Traffic Accidents

Traffic accident data for affected street corridors may be required for the study. The study period will normally be three years. Such locations will be specified by the Engineering Division. Where this is necessary, estimates of increased or decreased accident potential shall be evaluated for the development, particularly if the proposed development might impact existing traffic safety problems in the study area and safety improvements recommended where necessary.

Noise Attenuation

If a residential development is planned adjacent to a freeway or arterial roadway, the need for noise attenuation measures may be required as part of the impact analysis. It is recommended that the need for noise attenuation measures be determined using the methods outlined in Colorado Department of Transportation Noise Analysis and Abatement Guidelines, Latest Edition.

Recommendations

In the event that analysis indicates unsatisfactory levels of service on study area roadways, a description of proposed improvements to remedy deficiencies shall be included. These proposals would include projects by the City or the

Colorado Department of Transportation for which funds have been appropriated and obligated. The assumptions regarding all existing and future roads in an analysis will require approval from the Engineering Division. In general, the recommendation section should include:

- Proposed Recommended Improvements
- This section must describe the location, nature and extent of proposed improvements to assure sufficient roadway capacity. A sketch of each improvement should be provided showing the length, width and other pertinent geometric features of the proposed improvements.
- Level of Service Capacity Analysis at Critical Points
- Another iteration of the operational analysis shall be described which demonstrates the anticipated level of service as a result of making these improvements. This Level of Service must be "D" or better.
- Traffic Volume Proportions
- Percentages based on the traffic impact analysis may be required by the City to determine the proportion of traffic using various public improvements (both existing and proposed) from several developments within the study area.

Conclusions

This last section of the report must be a clear, concise description of the study findings explained in a manner that a citizen could understand as the language in this section will be inserted into the Planning Commission and City Council agenda memorandums. At minimum, the summary will include information pertaining to existing site generated traffic, impacts and mitigation measures and when they will be implemented.

Revisions to Traffic Study

Revisions to the traffic study shall be provided as required by the Engineering Division. The need to require revisions will be based on the completeness of the traffic study, the thoroughness of the impact evaluation and the compatibility of the study with the proposed access and development plan.

Summary of Typical Study Contents

- Introduction
    1. Land Use, Site and Study Area Boundaries (provide map)
    2. Existing and Proposed Site Uses and Circulation (provide map)
    3. Existing and Proposed Uses in Vicinity of Site (provide map)
    4. Existing and Proposed Roadway and Intersections (provide map)
- Trip Generation and Design Hour Volumes (provide table)
- Trip Distribution (provide figure)
- Trip Assignment (provide figure)
- Existing and Projected Traffic Volumes (provide figure for each item):

1. A.M. Peak Hour Site Traffic (including turning movements)
2. P.M. Peak Hour Site Traffic (including turning movements)
3. A.M. Peak Hour Total Traffic (including site-generated traffic and projected traffic)
4. P.M. Peak Hour Total Traffic (including site-generated traffic and projected traffic)
5. Any Other Peak Hour Necessary for Complete Analysis
6. Total Daily Existing Traffic for Street System in Study Area
7. Total Daily Existing Traffic for Street System in Study Area and New Site Traffic
8. Total Daily Existing Traffic for Street System in Study Area plus New Site Traffic and Projected Traffic from Build-Out of Study Area Land Uses

- Level of Service
- Capacity Analysis (provide analysis sheets in appendices)
- Traffic Signals (provide analysis sheets in appendices)
- Traffic Accidents (optional) (provide collision diagrams and accident rates)
- Noise Attenuation
- Conclusions
- Recommendations
    1. Proposed Recommended Improvements (provide sketches of improvements)
    2. Volume/Capacity Analysis at Critical Points (provide analysis sheets in appendices)
- Traffic Volume Proportions

NOTE: Information required on figures may be combined provided that the information is clearly legible.

5.5.5 Reports

Submittal Format

All reports shall be bound in an 8 ½-inch x 11-inch folder and shall include the seal and signature of the Professional Engineer registered in the State of Colorado who is responsible for the report contents. In addition, all reports shall include the following statement:

"We acknowledge that the City of Northglenn's review of this study is only for general conformance with submittal requirements, current design criteria, and standard engineering principles and practices."

5.6 Pavement Design Report

All roadway construction in the City of Northglenn shall require a pavement design report. The report content shall be in accordance with these STANDARDS AND SPECIFICATIONS and shall include the following items:

- Prior to any roadway construction, the Responsible Party shall provide a pavement design report that recommends typical pavement structural sections based on the known site soil conditions. The report shall consist of the following:

- The report shall be prepared by or under the supervision of and signed by a PE registered in the State of Colorado and shall include the following information:

    1. Vicinity map to locate the investigated area.

    2. Scaled drawings showing the location of borings.

    3. Scaled drawings showing the estimated extent of subgrade soil types and EDLA/ESAL for each street.

    4. Pavement design alternatives for each street on a scaled drawing.

    5. Tabular listing of sample designation, sample depth, Group Number, Liquid Limit, Plasticity Index, percent passing the No. 200 sieve, Group Index, Unified and AASHTO Classification, and soil description.

        a. Proctor Compaction Curves.

        b. Subgrade support testing of each soil type used in the design. (see 503.6.(c))

        c. Pavement design computer printouts or nomographs properly drawn to show soil support, EDLA/ESAL, and structural number.

        d. Design calculations. Include for all phases of project.

        e. Design coefficient used for asphalt, base course, etc.

        f. A discussion regarding potential subgrade soil problems including, but not limited to:

    6. Recommendations to alleviate or mitigate the impact of problems discussed above.

5.7 Pavement Evaluation Report

After installation of the concrete pavement or bituminous surface course except for the final two (2) inches on residential streets, the Developer may be required to furnish the Engineering Division with a copy of a report prepared by a Professional Engineer registered in the State of Colorado utilizing non-destructive deflection testing to access and predict the performance of the pavement. This testing may be required if evidence exists that the pavement section may not meet the design specifications. The Professional Engineer shall have a history and knowledge in performing these tests. Qualifications of Professional Engineers shall be submitted to the Engineering Division for approval before the start of work.

The pavement evaluation shall be performed in accordance with good engineering practices. The report shall generally embody the following testing and pavement evaluation techniques:

- Pavement Surface Elevation
- Soil Borings in Areas of High Deflections
- Pavement Deflection Analysis
- Environmental Study (Frost Cycle, Drainage, etc.)

The report shall evaluate the existing condition of the base and binder course by performance of deflection tests at 100- foot spacing per traffic lane. Spacing will be staggered in each lane. The report shall determine whether the pavement section will meet a 20-year pavement life or greater.

If the pavement section is not projected to meet a life expectancy of 20 years or more, the report shall propose asphalt overlays in excess of the existing pavement section to bring the new pavement section to a 20-year life expectancy. The Engineering Division will evaluate the results of the report and inform the developer of the acceptable solution mentioned in the report.

5.8 Pavement Design & Technical Criteria

5.8.1 General

Recommended design methodologies for asphalt follow the Colorado Department of Transportation's "Pavement Design Manual", latest edition (the "Manual").

For all City land development approvals that involve a Public Improvements Agreement for roadway construction, the applicant shall provide a subgrade investigation and pavement design report that recommends a typical pavement structural section based on the known site soil conditions and the approved traffic study or in accordance with the criteria set forth in these STANDARDS AND SPECIFICATIONS. This pavement design serves as a justification of the roadway structural requirements.

5.8.2 Subgrade Investigation & Pavement Design Report

The report shall be prepared by or under the supervision of and signed and sealed by a Professional Engineer registered in the State of Colorado and shall include the following information:

- Vicinity map to locate the investigated area.
- Scaled drawings showing the location of borings. Scaled drawings showing the estimated extent of subgrade soil types and ESAL for each street.
- Pavement design alternatives for each street on a scaled drawing.
- Tabular listing of sample designation, sample depth, group number, liquid limit, plasticity index, percent passing the No. 200 sieve, AASHTO classification, group index, and soil description.
- R-value test results of each soil type used in the design.
- Pavement design nomographs properly drawn to show soil support -- ESAL - SN. A computer printout may be used if the DARWin'" program is used.
- Design calculations.

- A discussion regarding potential subgrade soil problems including, but not limited to:

    1. Swell or settlement-prone soil.
    2. Frost-susceptible soils.
    3. Ground water.
    4. Drainage considerations (surface and subsurface).
    5. Cold-weather construction (if appropriate).
    6. Other factors or properties which could affect the design or performance of the pavement system.

Recommendations to alleviate or mitigate the problems discussed in above.

5.8.3 Field Investigation

The geotechnical investigation shall consist of borings or other suitable method of sampling subgrade soils to a depth of at least five (5) feet below proposed subgrade elevation, with a 10-foot boring every third hole, at spacings of no more than 250 feet unless otherwise accepted by the Development Engineering Manager. Samples shall be taken after grading is completed and the subgrade is rough cut.

5.8.4 Classification Testing

Each subgrade sample shall be tested to determine liquid limit, plastic limit, plasticity index and the percentage passing the U.S. Standard No. 200 sieve. Samples of sands and gravels may require gradation analysis for classification determination. These data shall be determined using the following methods:

- Liquid Limit - AASHTO T 89
- Plastic Limit - AASHTO T 90
- Percent Passing No.200 - AASHTO T II
- Gradation - AASHTO T 27

The results of these tests shall be used to calculate the AASHTO Classification and Group Index using AASHTO M 145.

If the Plasticity Index (PI) of the subgrade is more than 15 or the R-value of the soil is less than 10, then the subgrade shall be stabilized with one of the methods outlined in the “Manual".

5.8.5 Subgrade Support Testing

Individual subgrade samples shall be tested to determine the subgrade support value using Hveem Stabilimeter (R-value), or California Bearing Ratio (CBR) and Unconfined Compressive Strength (Qu) testing, or direct measurement of resilient modulus of soil AASHTO T-307. These values shall be used in the design of pavement sections in accordance with the procedures outlined below. Tests shall be conducted in accordance with this procedure.

R-Value Tests - Hveem Stabilimeter tests shall be conducted in accordance with AASHTO T 190. The design R-value shall be at 300 pounds per square inch (psi) exudation pressure. The reported data shall consist of:

- Dry density and moisture content for each sample.
- Expansion pressure for each sample.
- Exudation Pressure - corrected R-value curve showing the 300-psi design R- value.

CBR Tests: California Bearing Ratio Tests shall be conducted in accordance with AASHTO T193 with the following modifications:

- Note 4 of AASHTO T193 shall not apply. A three (3) point CBR evaluation is required.
- The compaction method used for the CBR test shall be determined by the soil classification.
- Surcharge shall be calculated using a unit weight of 140 pounds per cubic foot for HMA and 135 pounds per cubic foot for ABC.
- The design CBR value shall be determined from the CBR dry density curve and shall be the CBR value at 95 percent compaction.
- In addition to the values requested in AASHTO T193 Stress Penetration curves for each sample, a CBR dry density curve and Proctor compaction test results shall be reported.

5.8.6 Minimum Pavement Section

This paragraph provides the minimum acceptable pavement sections for public roadways in the City of Northglenn. These pavement thicknesses may be used for preliminary planning purposes. Final pavement designs must be based on actual subgrade support test results. Table 5.2 lists these minimum thicknesses for each roadway classification.

Table 5.2: Minimum Pavement Thickness

Composite Section			Full Depth	Portland Cement
Classification	Asphalt (inches)	Aggregate Base Course (inches)	Asphalt (inches)	Concrete (inches)
Cul-de-sac	--	--	6.0	6.0
Local	4.0	8.0	6.0	6.0
Major Collector	4.0	8.0	8.0	7.0
Arterial	6.0	8.0	10.0	9.0

(1)Concrete streets are only allowed with specific written approval of the Engineering Division.
(2) "Full Depth Asphalt" is required on all "Public Streets". Composite sections will only be allowed when specifically approved by the Engineering Division.
(3)All cul-de-sacs shall be the minimum full depth shown or the full depth determined by the subgrade support tests, whichever is greater.

5.9 Pavement Design Procedure

5.9.1 Flexible Pavements

The following procedure should be used in determining the Structural Number (SN) of the pavement being designed:

- Determine roadway classification and corresponding EDLA/ESAL.
- Determine the Serviceability Index (SI) of the roadway classification.
- Determine the reliability (R) of the roadway classification.
- Approved proper nomographs.
- Determine the required structural number using AASHTO pavement design software or nomographs from AASHTO or CDOT along with soil support test results and EDLA/ESAL values previously determined. If used, copies of the nomograph determinations must be included with the design submittal:

Once the Structural Number (SN) has been determined, the design thicknesses of the pavement structure can be determined by the general equation:

SN = a(1)D(1) + a(2)D(2) + a(3)D(3) + ...

Where A(1), Aa(2), Aa(3), Aa(n) = strength coefficients D(1),D(2),D(3),D(n) = thickness of pavement component sections. The strength coefficients for various components of the pavement structure.

- The component thickness selected must meet two (2) conditions:
    1. Total thickness selected cannot be less than the minimum specified in Table 500-1 for the roadway classification.
    2. The base course thickness selected cannot exceed two and one-half (2.5) times the asphalt thickness selected.
- Pavement section calculations shall be rounded up to the next thickness one-half (1/2) inch increment.
- The standard deviation for design of asphalt pavements shall be forty-four-hundredths (0.44).
- The design must reference any mitigation measures required when the subgrade contains swelling soils. Design reports recommending alternative methods or materials to address swelling soils (i.e., base course, lime, cement, etc.) must present the measures to be used to ensure adequate drainage of such layers and to maintain separation of the layers from the swelling soils. Swell tests shall be conducted for samples with probable expansion (volume change estimate) greater than two (2) percent based on actual tests. Surcharge pressure shall be 150 pounds per square foot, or as specified by the Development Engineering Manager.

5.9.2 Rigid Pavement

Rigid pavements are those that possess a high bending resistance and distribute loads over a large area of foundation soil. Examples include Portland cement concrete pavement or Portland cement concrete surfaced with asphalt. Rigid pavement shall only be utilized as specifically authorized by the Development Engineering Manager.

The design of rigid pavements is a function of support characteristics of the subgrade soil (R-value, CBR, or resilient modulus), traffic (EDLA/ESAL), and the strength of the concrete (working stress). In comparison to the strength of the concrete slab, the structural contributions of underlying layers to the capacity of the pavement are relatively insignificant. Therefore, the use of thick bases or subgrades under concrete pavement to achieve greater structural capacity is uneconomical and is not recommended.

Use the following procedure to obtain required thickness:

- Determine roadway classification and corresponding EDLA/ESAL.
- Determine design Serviceability Index (SI) of the roadway.
- The working stress of the concrete (Ft) used in the design shall be 75 percent of that provided by third- point beam loading, which shall have a minimum laboratory 28-day strength of 600 pounds per square inch based on actual tests of materials to be used.
- The reliability factor for design of all concrete pavements shall be 90 percent.
- The standard deviation for design of concrete pavements shall be between three-tenths (0.30) and four-tenths (0.40).
- Determine the structural numbers using AASHTO pavement design software. Nomographs of the AASHTO or CDOT parameters may be used instead. If used, copies of the nomograph determinations must be included with the design submittal.
- Using EDLA/ESAL and working stress data, locate point on the pivot line; connect this point to the R-value or CBR value on the soil support scale to determine slab thickness.
- Use slab thickness. (rounded upward to the nearest one-half (1/2) inch) or the minimum thickness from.
- For swelling soils (swell potential greater than two (2) percent, under 200 pounds per square foot surcharge pressure) concrete paving shall not be permitted without subgrade treatment.
- Pavement joint detail plans. With rigid pavement designs, the construction plans shall include a joint pattern layout for each street, alley, or intersection. All joints and joint filling in rigid pavements shall be designed and detailed in accordance with the current CDOT M&S Standards.