# Appendices

# Section

12 December 2005

# Appendix 1

# DEFINITIONS

# Item 1 – Document Terminology

Meanings of "Shall", "Should" and "May"

In the STANDARDS, the words "shall", "should" and "may" are used to describe specific conditions and are commonly used in specifications or requirements documentation. To clarify the meanings intended in the STANDARDS by the use of these words, the following definitions apply:

**shall** – a mandatory condition. Where certain requirements in the STANDARDS are described with the "shall" stipulation, it is mandatory that these requirements be met.

**should** – an advisory condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.

**may** – a permissive condition. No requirement for design or application is intended by its use. Where “may” is used, a suggestive option or consideration is intended.

# Item 2 – Definitions and Acronym Translation

Wherever the following words, phrases or abbreviations appear in the STANDARDS, they will have the following meanings:

**ΔPSI** – see PSI

**AASHTO** – The American Association of State Highway and Transportation Officials.

**AADT** – annual average daily trips

**ABC –** aggregate base course

**ADT** – average daily trips

**Average Daily Trips –** the 24 hour traffic volume averaged over a stated period of time, typically one year.

**Agricultural Road –** any road whose use is to serve an agricultural operation.

**Agriculture –** the use of the land for the primary purpose of making a profit from farming or ranching and include:

- The production, cultivation, growing, and harvesting of plant crops, but not including the harvesting of trees unless incidental to other agricultural operations;
- The raising and/or the breeding of livestock including horses, dairy and beef cattle, sheep, goats, fur-bearing animals, poultry and swine;
- The production of nursery products and sod;
- The harvesting, storage, grading, packaging, processing, distribution, and sale or trade of such commodities where such activities occur at the point of production.

It specifically does not include the uses, structures and retail services normally associated with kennels, veterinary hospitals, the commercial slaughter of animals, and commercial riding stables.

**ASTM** – The American Society for Testing Materials.

**BOCC –** the Delta County Board of County Commissioners

**CDOT** – Colorado Department of Transportation

**Collector Road** – a functional classification of a road characterized by an emphasis on mobility with land access. Conceptually, a collector road would be accessed from a minor arterial road and lead to a local access road in traffic flow strictly defined by functional hierarchy.

**Construction Inspector** – authorized representative of the County assigned to make inspections for assurance of compliance of construction with the approved plans and these STANDARDS.

**Construction Plans** – detailed working plans including plan and profile, details, notes and other information necessary for complete construction of the required improvements.

**Contractor** – a person, partnership, or corporation performing work within the public right-of-way

**County** – Delta County, Colorado

**County Road** – only those public roads that have been incorporated into the County Road System as shown on the BOCC adopted Delta County Road Map system.

**C.R.S.** – Colorado Revised Statutes

**Culvert** – a closed conduit, not to include a bridge, which conveys water carried by a natural channel or waterway transversally under a roadway or driveway.

**Cut** – when used in the context of road construction or excavation, refers to an activity or an area in which material has been removed to address terrain grade for design purposes. Cuts are performed to provide a level area for roads placed against hillsides, for example.

**Dedication** – the deliberate appropriation of land by an owner for any public use, reserving no rights which would be incompatible with the full exercise and enjoyment of the public use to which the property has been devoted. The transfer may be of fee-simple interest or of a less than fee-simple interest, including an easement.

**Design Speed** – a speed determined for design and correlation of physical features of a road that influence vehicle operation; the maximum safe speed maintainable on a specified section of road when conditions permit design features to govern. Design speed is generally higher than the posted speed limit in order to provide a factor of safety and consider other conditions or uses of the road, which may affect vehicle operation.

**Developer** – person, partnership or corporation legally responsible for the construction of roads within a subdivision or development.

**Driveway –** an access to a sole private, commercial, or public site.

**Driveway, shared –** a driveway providing access to two separate lots. The purpose for a shared driveway is to minimize access impact or to address circumstances for which a road would be an over-requirement. Shared accesses servicing more than two lots will be categorized as a road and not a driveway.

**Easement –** a grant or authorization by a property owner for the use of land by others for a specified purpose.

**FEMA –** Federal Emergency Management Agency

**FHWA** – the Federal Highway Administration.

**Fill –** when used in the context of road construction or excavation, refers to an activity or an area in which material has been added to address terrain grade for design purposes. Fills are used to remove gulches along the path of a roadway, for example.

**Grade –** a vertical slope rate expressed in terms of percentage defined by a change in height divided by the horizontal length over which the height change occurred.

**ITE –** Institute of Transportation Engineers

**Level of Service –** a rating of roadway quality using a letter rating system of A (best) to F (worst). The level of service rating characterizes roadway performance based on criteria involving speed, travel time, freedom to maneuver, traffic interruptions, comfort, and convenience. Reference the Highway Capacity Manual, Transportation Research Board for a complete rating source.

**Level Terrain –** a terrain classification where road sight distances, determined by both horizontal and vertical restrictions, are generally long or can be made so with minor terrain alteration would be characterized by an average natural cross slope of less than eight (8) percent.

**Local Access Road –** a functional classification of a road characterized by traffic movement with maximum emphasis on land access from abutting properties to collector roadways. Conceptually, a local access road would be accessed from a collector road and lead to a local service road in traffic flow strictly defined by functional hierarchy.

**Local Service Road –** a functional classification of a road characterized by traffic movement solely intended for land access from abutting properties to local access or collector roadways, typically from isolated sites with little potential for future development. Conceptually, a local service road would be accessed from a local access road and lead to a driveway.

**LOS –** level of service; used in reference to roadway performance quality.

**Minor Arterial Road –** a functional classification of a road characterized by traffic movement of a town to town nature emphasizing mobility. Conceptually, a minor arterial road would be accessed from a principal arterial road and lead to a collector road in traffic flow strictly defined by functional hierarchy.

**Mountainous Terrain –** a terrain classification where longitudinal and transverse changes in elevation of the ground with respect to the road are abrupt and where the roadbed is obtained by frequent benching or side hill excavation. This would be characterized by an average natural cross slope in excess of fifteen percent.

**MUTCD –** Manual on Uniform Traffic Control Devices for Streets and Highways (a Federal Highway Administration publication)

**New road / new road construction** – this designation applies to any and all of the following:

a. A road created by new subdivision process where no road previously existed.

b. A road which previously existed but was not accepted for maintenance by Delta County in which a request is being made that the County accept the road for maintenance.

c. A road where a platted or deeded right-of-way has previously existed but the road was never physically constructed.

**Passing Sight Distance –** the minimum sight distance for a vehicle to safely pass another vehicle without affecting an oncoming vehicle traveling at the design speed which appeared after the passing maneuver was initiated. The point of view height for the sight distance measurement would be 3.5 feet and the object height would be 3.5 feet

**Principal Arterial Road –** a functional classification of a road characterized by corridor traffic movement with maximum emphasis on mobility. Conceptually, a principal arterial road would be accessed from an interstate roadway and lead to a minor arterial in traffic flow strictly defined by functional hierarchy.

**Primitive Roads –** Limited or seasonal use roads only. Historical or rudimentary roads – rough, narrow and typically used for recreational access or possibly commercial uses.

**Private Road** – any roadway that is not a public road, not associated with any public right-of-way and not intended for general public use. A private road may have a right-of -way for specific users or have an exclusive easement associated with its use. Such arrangements do not alter the road's classification from being private.

**Proof Roll –** a load test of subgrade, sub-base or base course compaction using and observing a loaded tandem axle truck with a gross vehicular weight of 50,000 to 54,000 lbs. The test covers the entire surface with the truck wheels to demonstrate the stability and load bearing capacity of the test section.

**Public Road** – below are definitions that apply to this designation:

a. All roads over private lands dedicated to the public use by deed to that effect, filed with the office of the County Clerk and Recorder when such dedication has been accepted by the Board;

b. All roads over private or other lands dedicated to public uses by due process of law, including a subdivision plat approved by the County and recorded in the office of the County Clerk and Recorder, and not heretofore vacated by an order of the Board duly entered of record in the proceedings of the Board;

c. All roads over private lands that have been used adversely without interruption or objection on the part of the owners of such lands for 20 consecutive years; as defined by Colorado law;

d. All roads over the public domain whether of an agricultural or mineral extraction use.

**PSI –** present serviceability index

**ΔPSI –** serviceability loss

**psi –** pounds per square inch

**Public Use - Privately Maintained Road** – a Public Road which is not a County Road and has not been accepted for maintenance by the County, thereby being the responsibility of a private party for upkeep, maintenance, repairs, and snowplow needs. This category of roadway is typically the result of a subdivision development.

**Return Radius –** the dimension which defines the curvature of a road return.

**Right-of-Way –** a general term denoting land, property, or interest therein, usually in the form of a strip, acquired for or devoted to a roadway and under County authority.

**Road Return** – at an intersection, the blended area at road edge between the intersecting roads allowing turning vehicles additional traveled surface than that strictly defined by lane width. The return is typically defined by a line of curvature dimensioned with a pure radius or can be a compound radius shape.

**Rolling Terrain** – a terrain classification where the natural slopes consistently rise and fall below the road grade line and where occasional steep slopes offer restriction to normal horizontal and vertical alignment. This would be characterized by an average natural cross slope from eight to fifteen percent.

**ROW –** right-of-way

**Rural –** an area which can be characterized as less developed with low density residential levels and a high degree of agricultural or open space land usage.

**Shoulder –** the portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, emergency use, and for lateral support of roadway base and surface structure.

**Sight Distance –** the distance, as measured along the roadway, throughout which an object is continuously visible to driver. Sight distance will have a point of view height and an object height associated with it which are dependent on the sight distance use.

**SSD** – stopping sight distance

**STANDARDS** – the Delta County Roadway Design and Construction Standards

**Stopping Sight Distance –** the sight distance for a vehicle at a specific speed to come to a complete stop. The point of view height for the sight distance measurement would be 3.5 feet and the object height would be 2 feet.

**Sub-base** – the layer or layers of specified or selected material of designed thickness placed on the sub-grade to support a base course.

**Sub-grade** – the top surface of a roadbed upon which the pavement structure and shoulders, including curb and gutter, are constructed.

**Superelevation** – the raised portion of a roadway above the normal cross slope to prevent a vehicle from sliding outward from centrifugal force.

**Traveled Way –** the portion of a roadway intended for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

**Urban** – an area which can be characterized as developed with high density residential levels and can consist of a high degree of commercial or industrial land usage. Residential densities averaging one dwelling unit or more per acre would constitute a high density residential situation.

**USDA** – United States Department of Agriculture

**VPC** – vertical point of curvature. The VPC is a parameter in determining the length of a crest vertical curve for purposes of determining stopping sight distances.

**VPI** – vertical point of intersection. The VPI is a parameter in determining the length of a crest vertical curve for purposes of determining stopping sight distances.

**VPT** – vertical point of tangency. The VPT is a parameter in determining the length of a crest vertical curve for purposes of determining stopping sight distances.

# Appendix 2

# Documentation Requirements

# Item 1 – Construction Drawing Requirements

## General Requirements

The construction drawing submittal consists of a complete package which includes all details of plan, profile, cross-sectional views and documentation necessary for the construction of the proposed improvements. All drawings will be prepared by or under the direction of a professional engineer licensed to practice in the State of Colorado.

## Cover Sheet

A cover sheet will be provided with each submittal involving multiple roads or sheets. Cover sheets will contain:

a. A vicinity map at a minimum scale of 1" = 2000' which shows the location and names of all arterial or collector roads within one mile of the development and all roads within the proposed development.

b. Legend.

c. Name or company name, address, and phone number of the engineer preparing the plans.

d. General notes.

e. Description and location of permanent vertical benchmarks based on U.S.G.S datum. Where it is not practical, due to lack of available existing benchmarks in the area of the development, the plans may reflect an assumed bench elevation upon the approval of the Board of County Commissioners. In the case of an assumed bench elevation, a minimum of two benchmarks will be established and identified on the plan. All such benchmarks will be located within the proposed development or within public right-of way adjoining the development.

f. Names and phone numbers of all utility companies with mains, lines or facilities potentially impacted by the construction.

## Plan and Profile Sheets

Plan and profile sheets will be submitted for all proposed roadway construction. Plan view will include, but not be limited to, the following:

a. The scale will be 1” = 50’.

b. Locations and dimensions of existing and proposed property lines, easements, and right-of-ways.

c. Lot numbers and lot lines and dimensions if the road is within a platted subdivision.

d. Road names.

e. Survey and project centerline stationing.

f. Centerline stations for all intersecting roads, public and private, and for commercial or industrial driveways.

g. Existing improvements will be depicted by dashed lines and proposed improvements by solid lines. Existing and proposed road improvements include curb and gutter, sidewalk, pavement, culverts, guardrail, etc., and include all structures and appurtenances, whether public or private, within the right-of-way.

h. Curve information including radius, interior angle, curve length, and tangent.

i. Elevation and stationing for all curb returns, points of curvature, points of tangency, angle points and high or low points of vertical curves.

j. Rate of superelevation if applicable.

k. Match lines and adjoining sheet numbers.

l. Existing and proposed utilities, both overhead and underground, including but not limited to water, sewer, electric, gas, telephone, storm sewer, and cable television.

m. Stations and critical elevations of all utility and drainage appurtenances, existing and proposed.

n. Traffic control signing and striping.

o. Erosion control measures.

p. Landscaping.

Plan view will include, but not limited to:

a. Vertical scale of a minimum of 1" = 5'.

b. Existing grades will be depicted with dashed lines; proposed grades will be depicted with solid lines.

c. Continuous stationing for the entire portion of roadway shown in the plan view, with the centerline stationing of all intersecting roadways, public and private, and commercial and industrial driveways clearly labeled.

d. All design elevations will represent roadway centerline finish elevations. Additional profile views of curb and gutter, etc., will be included as needed for clarity.

e. Vertical curve data including length of curve and stationing and elevation of VPT, VPI, VPC, and high/low point.

## Cross Sections

Cross sections that include earthwork calculations at least every 50 feet and clearly show the proposed method of widening or matching into existing improvements or method of handling steep side slopes and the rights of way lines are required.

## Striping and Signing Plan

The signing plan will show at a minimum:

a. Location of all existing and proposed signs, clearly indicating if existing signs are to remain.

b. Legend with reference to standard MUTCD designations.

c. Typical detail of installation dimensions.

d. Blank gauge and material of signs.

e. Note reflectorization provided – high intensity encapsulated sheeting.

The striping plan will show at a minimum:

a. Striping material (paint, thermoplastic, etc.).

b. Color designation and line width.

c. Lane width.

d. Line type (solid, skip, etc.).

e. Typical details for any acceleration/deceleration lanes, turning lanes, crosswalks, etc.

## Details

Delta County Standard Details or Colorado Department of Transportation Standard Details may be referenced without being reproduced on the plans where no modification to a standard is proposed or required. Any modifications to standards will require a specific detail to be included.

## Standard Notes

The following general notes will appear on the cover sheet or first sheet of all construction plan sets:

a. The contractor will provide all signs, barricades, flaggers, and devices necessary to comply with the requirements of the latest edition of the Manual on Uniform Traffic Control Devices. No work within any County right-of-way may begin until a traffic control plan has been submitted to and approved by the Road and Bridge Department.

b. The contractor will notify the Road and Bridge Department at least seven days before starting construction of any public improvements or any construction within the County right-of-way.

## Summary of Approximate Quantities

A Summary of Approximate Quantities table will be provided in the plans. Each item and the quantities shown in the summary will be supported by tabulations or general notes within the plans.

## Record Set of Drawings

No set of construction plans will be considered to have final approval, nor will construction be allowed to begin until a complete record set copy of the plans have been submitted to the Engineering Department. The record set will be clearly marked “Record Set” and will bear the signature and seal of the professional engineer responsible for their preparation, on every sheet of the plans.

# Appendix 3

# Tables and Charts

## Item 1 - Road Design Criteria by Functional Classification

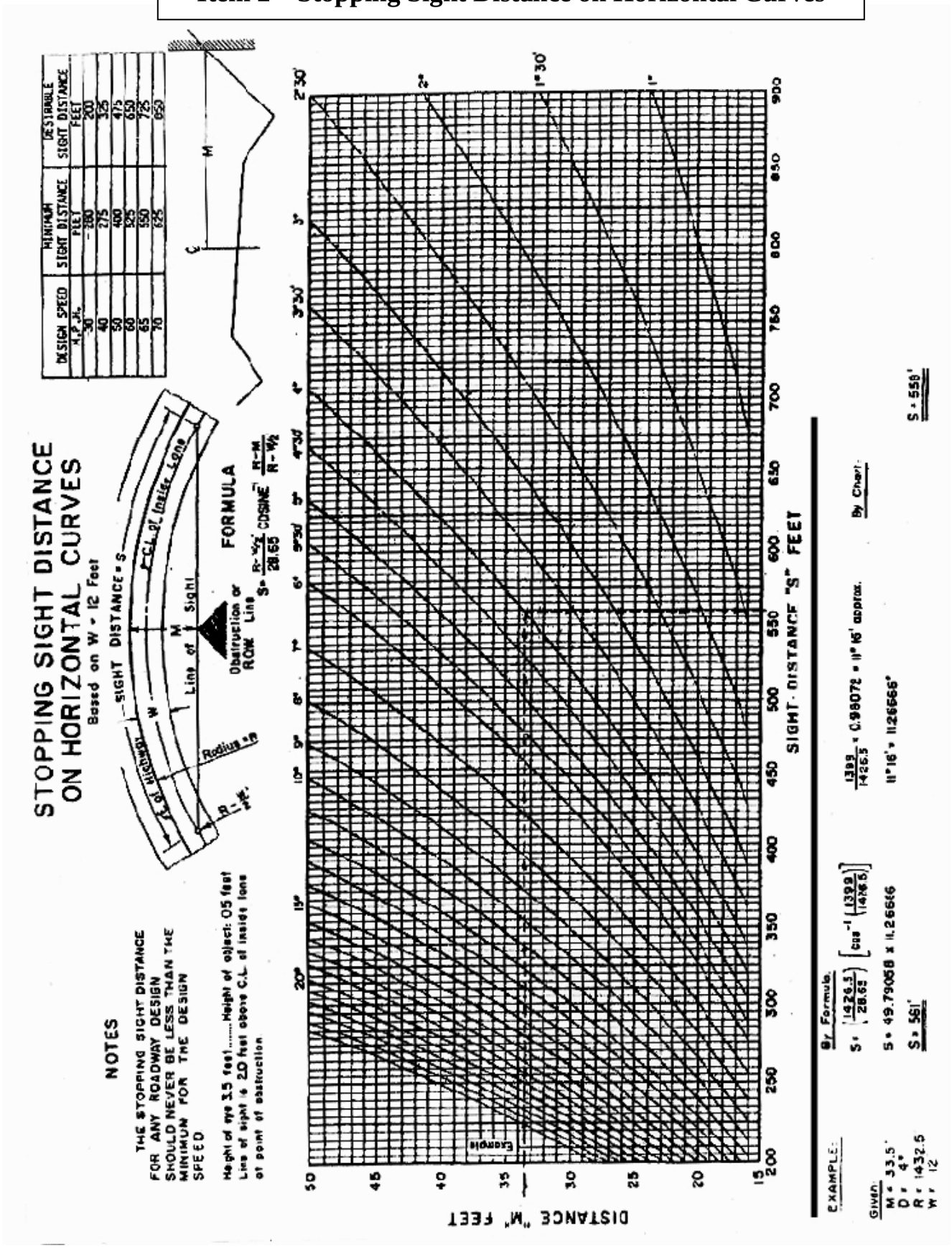
| Classification | ADT** Volume | Surface | Design Speed | | Minimum ROW | Lane Width | Shoulder*** Width |
|---|---|---|---|---|---|---|---|
| | | | level/rolling | mountainous | | | |
| principal arterial | 10,000+ | paved | 70 | 60 | 120 | 12 | 8 |
| minor arterial | 2,000 - 12,000 | paved | 60 | 50 | 100 | 12 | 6 |
| collector | 500 - 4,000 | paved | 45 | 40 | 80 | 12 | 4 |
| local access road | up to 500 | paved | 30 | 25 | 60 | 10 | 2 |
| local access road privately maintained* | up to 500 | paved or gravel | 30 | 25 | 60 | 7.5 | 2 |
| local service road | up to 100 | paved or gravel | 25 | 20 | 60 | 10 | 2 |
| local service road privately maintained* | up to 100 | gravel | 25 | 20 | 60 | 7.5 | 2 |

* a public use – privately maintained road

** ADT volumes provided as guidelines only to provide a sense of road use for each classification

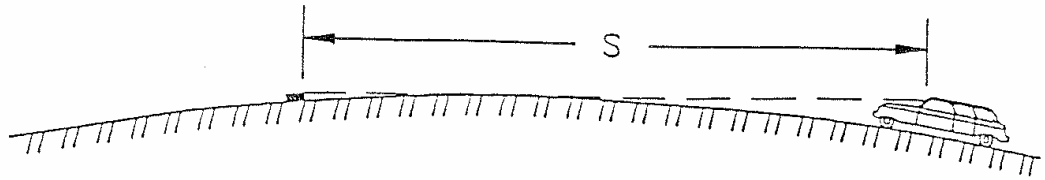
*** Roads above 7,000 feet elevation may require additional shoulder width for snow storage at the determination of the County Engineer.

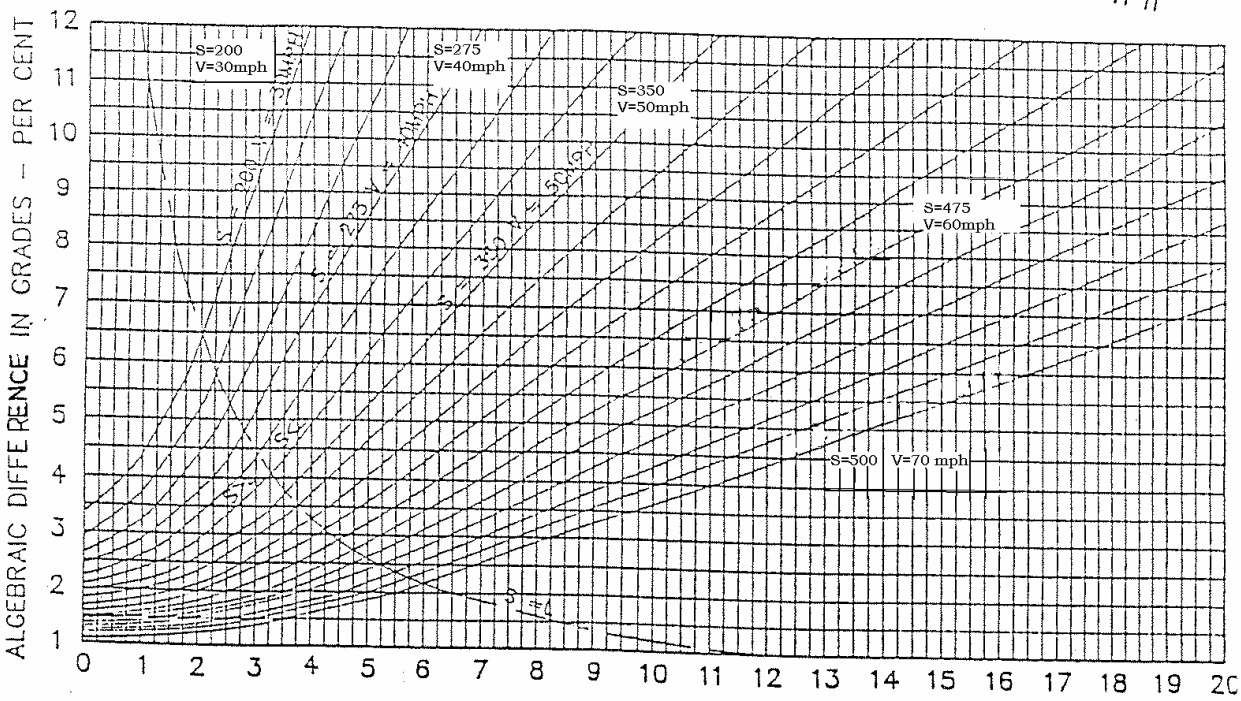
**Item 2 – Stopping Sight Distance on Horizontal Curves**



## Item 3
## Stopping Sight Distance on Crest Vertical Curves

HEIGHT OF EYE 3.5 FEET
HEIGHT OF OBJECT 6 INCHES




| WHEN S > L | WHEN S < L |
|---|---|
| $S = \frac{664.5}{A} + 50L$ | $S = 364.6\sqrt{\frac{L}{A}}$ |

L = Curve length – stations
A = Algebraic grade difference – %
S = Sight distance – ft.
V = Design speed – M.P.H. for "S"

| DESIGN SPEED M. P. H. | MINIMUM SIGHT DISTANCE FEET | DESIRABLE SIGHT DISTANCE FEET |
|---|---|---|
| 30 | 200 | 200 |
| 40 | 275 | 300 |
| 50 | 350 | 450 |
| 60 | 475 | 680 |
| 65 | 550 | 750 |
| 70 | 600 | 850 |

## Item 4

## Tangent Sections Between Curves in the Same Direction

On two lane roads, tangent sections are needed between two curves in the same direction. If the pavement cross sections through the curves do not have superelevation, the minimum lengths for tangent sections are listed in the following table:

| Design Speed (mph) | Tangent Length (ft) |
|---|---|
| 20 | - |
| 25 | 250 |
| 30 | 300 |
| 35 | 400 |
| 40 | 500 |
| 45 | 500 |
| 50 | 500 |
| 55 | 660 |
| 60 | 660 |
| 65 | 660 |

If superelevation is provided in the curved portions of the roadway, then the tangent lengths will be determined by the superelevation transition lengths, which will be in accordance with the AASHTO publication, A Policy on Geometric Design of Highways and Streets.

## Item 5

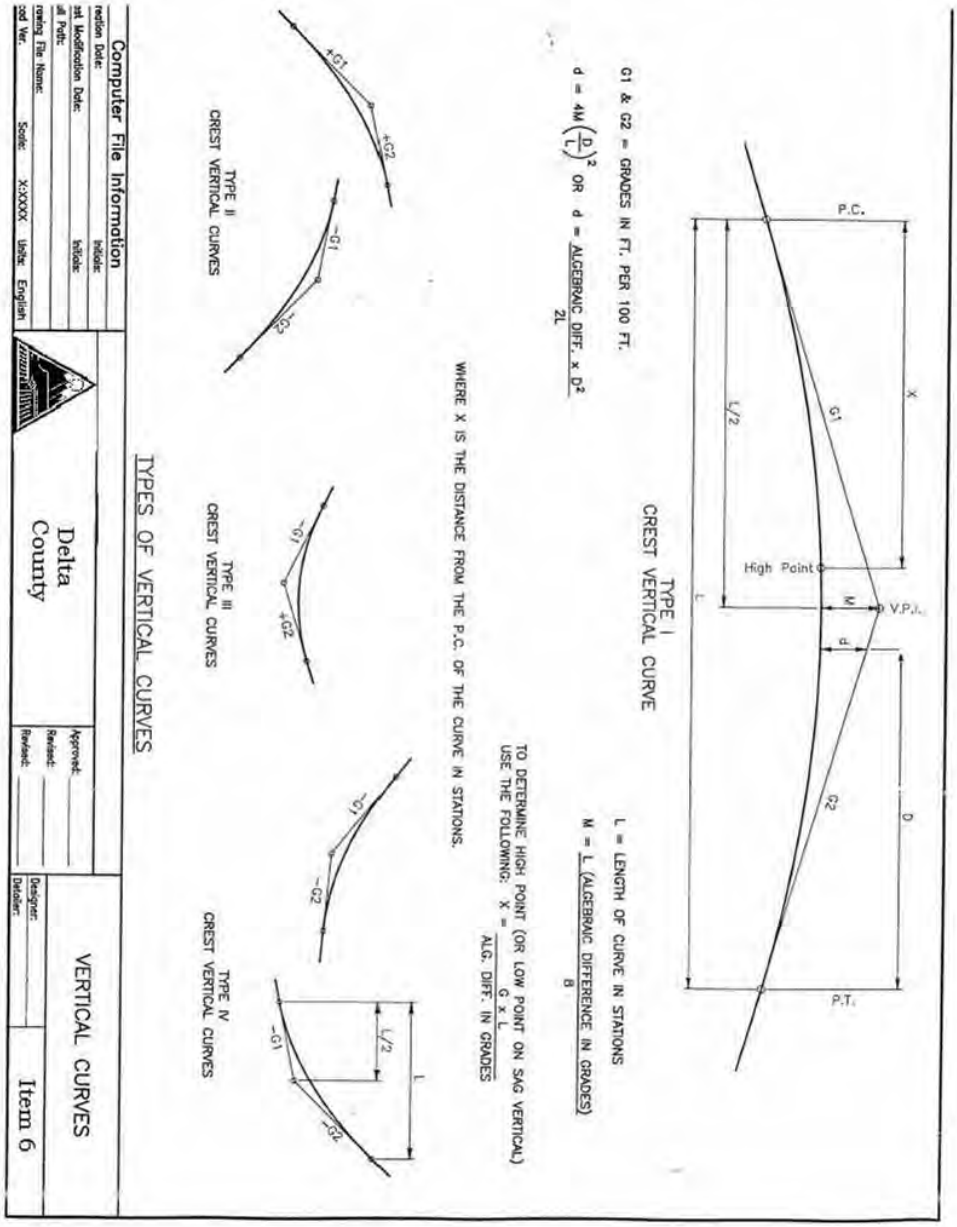
## Tangent Sections Between Reverse Curves

A tangent section must be provided between two curves that curve in the opposite direction. A tangent section must also be provided between an intersection and a curve. If the pavement cross sections through the curves do not have superelevation, the minimum lengths for such tangent sections are listed in the following table:

| Design Speed (mph) | Tangent Length (ft) |
|---|---|
| 20 | - |
| 25 | 100 |
| 30 | 150 |
| 35 | 200 |
| 40 | 250 |
| 45 | 250 |
| 50 | 300 |
| 55 | 300 |
| 60 | 400 |
| 65 | 500 |

If the curve radii are at least 50% greater than the radii required by the design speed, the tangent sections may not be required, depending on grades, topography and vegetation. If the curves are superelevated, the superelevation transition lengths will determine the minimum length of tangent sections between reverse curves.

# Item 6
## Vertical Curves



# Appendix 4

# Construction Design Standards

# Item 1
# Standard Details

**Pavement Structure Design**

It is the policy of Delta County that the surface of all new roads constructed within a public right-of-way classified as a local access road or higher will be hot bituminous pavement (asphalt) or Portland cement concrete pavement.

**Pavement Thickness**

The required thickness of pavement will be based upon the provisions of this section. In no case, however, will the thickness of hot bituminous pavement for a road to be maintained by the County be less than two and one half (2.5) inches after compaction.

**Pavement Structure Design Report**

A pavement design report will be submitted prior to the approval of any roadway construction plans involving new pavement, overlay of existing pavement or widening of existing pavement. The report will be prepared by a professional engineer licensed to practice in the State of Colorado.

The pavement design report will include the following minimum information:

a. Soil logs along the proposed roadway alignment at a maximum of 500 foot intervals. Logs will include a soil profile for a minimum depth of four feet below the proposed sub-grade elevation.

b. Each representative sample will be classified according to the AASHTO Unified Soil Classification Table and will have an Atterberg Limits Test and sieve analysis will be performed.

c. The pavement design procedure is based upon the resilient modulus, $M_R$, of the sub-grade soils. The value $M_R$ may be obtained from a HVEEM Stabilometer test ("R" value) by the following formulae:

to convert HVEEM "R" to soil support, $S_1$

$S_1 = [(\text{"R"}-5)/11.29] + 3$

To convert $S_1$ to $M_R$

$M_R = 10^{((S_1 + 18.72)/6.24)}$

d. Proposed average daily traffic volumes (ADT) for each road based on 100% of full development plus a 10% adjustment for construction traffic.

e. Recommended structural sections based on the design considerations, proposed typical sections, and the sections of roadway which may require additional stabilization or treatment.

**Design Considerations**

The following elements are to be used in the design procedure:

a. The design procedure is based on the number of 18,000 pound single axle equivalent load applications (18K EDLA) per traveled lane. In no case will the design 18K EDLA be less than the following values:

| | |
|---|---|
| Local Service | 5 |
| Local Access | 10 |
| Local Commercial | 30 |
| Local Industrial | 60 |
| Collector | 100 |
| Minor Arterial | 200 |
| Principal Arterial | 300 |

b. The serviceability loss, ΔPSI, for Local Roads will be 2.5; for Collectors and Arterials it will be 2.0.

c. The reliability factors used will be the following:

| | |
|---|---|
| Local Roads | 75 |
| Collectors | 80 |
| Minor Arterial | 90 |
| Major Arterial | 95 |

d. Overall standard deviation, $S_o$, will be 0.44 for all designs.

e. An adjustment to the structural layer coefficients for drainage conditions will not normally be needed for new construction. (Less than the fair drainage assumed under CDOT method would not be allowed under new construction). In no case will structural layer coefficients be modified by a factor greater than 1.0. In those instances where, due to existing constraints or physical conditions, occasional moisture levels within the base or sub-base may approach saturation, the following factors will apply:

| Quality of Drainage | Percent of time pavement is exposed to moisture levels approaching saturation | | |
|---|---|---|---|
| | < 1% | 1-5% | 5-25% |
| fair | 1.0 | 1.0 | 0.80 |
| poor | 1.0 | 0.80 | 0.60 |
| very poor | 0.95 | 0.75 | 0.40 |

f. Strength coefficients per one inch layer of a given material for layered pavement design

| | |
|---|---|
| Hot bituminous pavement | 0.44 |
| Class 6 base course | 0.12 |
| Class 2 sub-base course | 0.10 |

Strength coefficients for specially treated base materials for design purposes must be approved by the Board of County Commissioners.

**Structural Layers Design Details**

The minimum structural layer design for County roadways can be found in Appendix 5 – Typical Roadway Cross Sections and Designs for the appropriate road of interest. The County Engineer may approve alternative layered designs when geotechnical studies from a certified testing source approved by a professional engineer indicate options that would not compromise structural integrity.

**Subgrade:** The subgrade will be natural ground capable of supporting the proposed roadway. Wet, unstable or soft subgrade will require an engineered roadway design to address the substandard conditions.

One R value test will be taken for each soil type encountered in the proposed roadway layout within four (4) feet of the surface of the native ground. Submittal of test results to the County should be prior to road plan acceptance by the County. Minimum acceptance for the subgrade is an R value = 15 or greater. Results lower than the minimum will require an engineered roadway design to address the substandard conditions (see above).

The subgrade will be compacted to ninety (90) percent modified proctor density, AASHTO - T180, between minus two (-2) percent and plus three (+3) percent of optimum moisture.

Density tests will be performed every two hundred (200) lineal feet of the roadway or a minimum of two (2) tests.

**Sub-base:** A minimum of twelve (12) inches compacted thickness of aggregate sub-base meeting gradation and plasticity requirements of CDOT Class 2 aggregate is required. The sub-base will be compacted to ninety-three (93) percent modified proctor density, AASHTO - T180, between minus two (-2) percent and plus three (+3) percent of optimum moisture.

The County Engineer may approve a sub-base of less than twelve (12) inches should testing shows it would be adequate for the conditions. Sub-base thickness values of eight (8) inches or less will require the use of CDOT Class 1 aggregate for the sub-base material.

Density tests will be performed every one hundred (100) lineal feet of the roadway or a minimum of three (3) tests.

**Base Course:** A minimum of four (4) inches compacted thickness of aggregate base course meeting gradation, fracture, and plasticity requirements of CDOT Class 6 is required. The base course will be compacted to ninety-five (95) percent modified proctor density, AASHTO - T180, between minus two (-2) percent and plus three (+3) percent of optimum moisture.
Density tests will be performed every one hundred (100) lineal feet of the roadway or a minimum of three (3) tests.

**Proof Roll**

Upon completion of subgrade, subbase and base preparation, the Developer may, with the approval from the County Engineer, substitute compaction testing by proof rolling each or any layer with a heavy, rubber-tired piece of equipment in the presence of the County Inspector to demonstrate the stability, uniformity, and load carrying capacity of the layer. Any soft area identified during proof rolling will be repaired and proof rolled again prior to placement of the next layer.

**Full Depth Asphalt**

Full depth asphalt designs will not be allowed in Delta County except with the specific approval of the Board of County Commissioners, and will not be allowed on clay sub-grade soils.

## Layered Design Analysis

Layered structures (asphalt on aggregate base course) will be designed in accordance with the principals shown in Item 3 of this appendix. First, the structural number required over the sub-grade soil is computed. In the same way, the structural number required over the sub-base layer should also be computed, using the applicable strength values for each. By working with differences between the computed structural numbers required over each layer, the maximum allowable thickness of any layer can be computed. For example, the maximum allowable structural number for the sub-base material would be equal to the structural number required over the sub-base subtracted from the structural number required over the sub-grade soil. In a like manner, the structural numbers of the other layers may be computed. The thickness for the respective layers may then be determined as indicated in Item 3.

Required nomographs and tables related to paved roads are contained as part of this appendix with examples of pavement structure design can be found in Appendix 4.

## Gravel Road Design

The procedure accepted by Delta County for selection of base and sub-base thickness for gravel roads is based upon the AASHTO Guide for Design of Pavement Structures. Portions of this section including the tables and nomographs are taken from that publication.

### Factors

The allowable values for factors used in gravel road design are as follows:

a. Allowable rutting, RD = 2 inches

b. Gravel loss, GL = 2 inches

c. Serviceability loss, $\Delta PSI = 3.0$

d. Quality of roadbed soils for use in section f. below will be based upon HVEEM Stabilometer “R” value as follows:

| | |
|---|---|
| R < 15 | Very Poor |
| R = 15-25 | Poor |
| R = 25-35 | Fair |
| R = 35-55 | Good |
| R > 55 | Very Good |

e. Season lengths, in numbers of months, will be based upon U.S. climatic Region VI (Southwest Region, National Climatic Data Center), and are as follows:

| | |
|---|---|
| Winter (roadbed frozen) | 3.0 months |
| Spring thaw (roadbed saturated) | 1.5 months |
| Summer (roadbed dry) | 4.5 months |
| Spring/Fall (roadbed wet) | 3.0 months |

f. Seasonal roadbed soil resilient moduli, $M_R$ (psi), as a function of the relative quality of the road bed material will be as follows:

| Quality of Roadbed soil | Season (roadbed soil condition) | | | |
|---|---|---|---|---|
| | Summer | Winter | Spring-thaw | Spring/Fall |
| Very good | 20,000 | 2,500 | 8,000 | 20,000 |
| Good | 20,000 | 2,000 | 6,000 | 10,000 |
| Fair | 20,000 | 2,000 | 4,500 | 6,500 |
| Poor | 20,000 | 1,500 | 3,300 | 4,900 |
| Very poor | 20,000 | 1,500 | 2,500 | 4,000 |

An example of a gravel roadway design is contained within Appendix 7, including text descriptions of the design steps in the AASHTO method.

# Item 2
## Modifications to CDOT Specifications

The following modifications or additions are made to the Colorado Department of Transportation's Standard Specifications for Road and Bridge Construction. These modifications and additions will apply to all work covered under the STANDARDS.

a. Class 6 aggregate base course material will be crushed material, with at least 50 per cent of the material remaining on the #4 sieve having at least two fractured faces. No slag based Class 6 aggregate base course material will be allowed as a final surface treatment. Slag based Class 6 aggregate base course material will be acceptable for base material under a final asphalt or concrete paving course.

b. Aggregate for Hot Bituminous Paving will conform to the following:

   Grading C – 50 per cent of the material passing through the ¾ inch sieve and retained upon the #4 sieve will have a minimum of two fractured faces.

   Grading CX – 50 per cent of the material passing through the ½ inch sieve and retained upon the #4 sieve will have a minimum of two fractured faces.

c. Borrow Material – All borrow material used within the right-of-way will meet the following requirements and be subject to approval of the Engineering Department:

   All borrow material will be non-organic and contain no trash or perishables nor particles exceeding 4 inches in size, and will have a minimum dry density of 90 lbs./cu.ft.

   All borrow material will consist of material which is essentially a granular soil with a minimum "R" value of 40, a maximum liquid limit of 30, a maximum plasticity index of 6 and the following grain distribution:

| Sieve Designation | % Passing |
|---|---|
| 4 inch | 100 |
| #200 | 3-20 |

d. Culvert pipe – all culvert pipe installed within the public right-of-way will conform to one of the following:

Corrugated steel pipe – 16 gauge or heavier, annular or spiral with annular ends, in compliance with AASHTO designation M 36.

Reinforced concrete pipe – compliance with AASHTO designation M 170

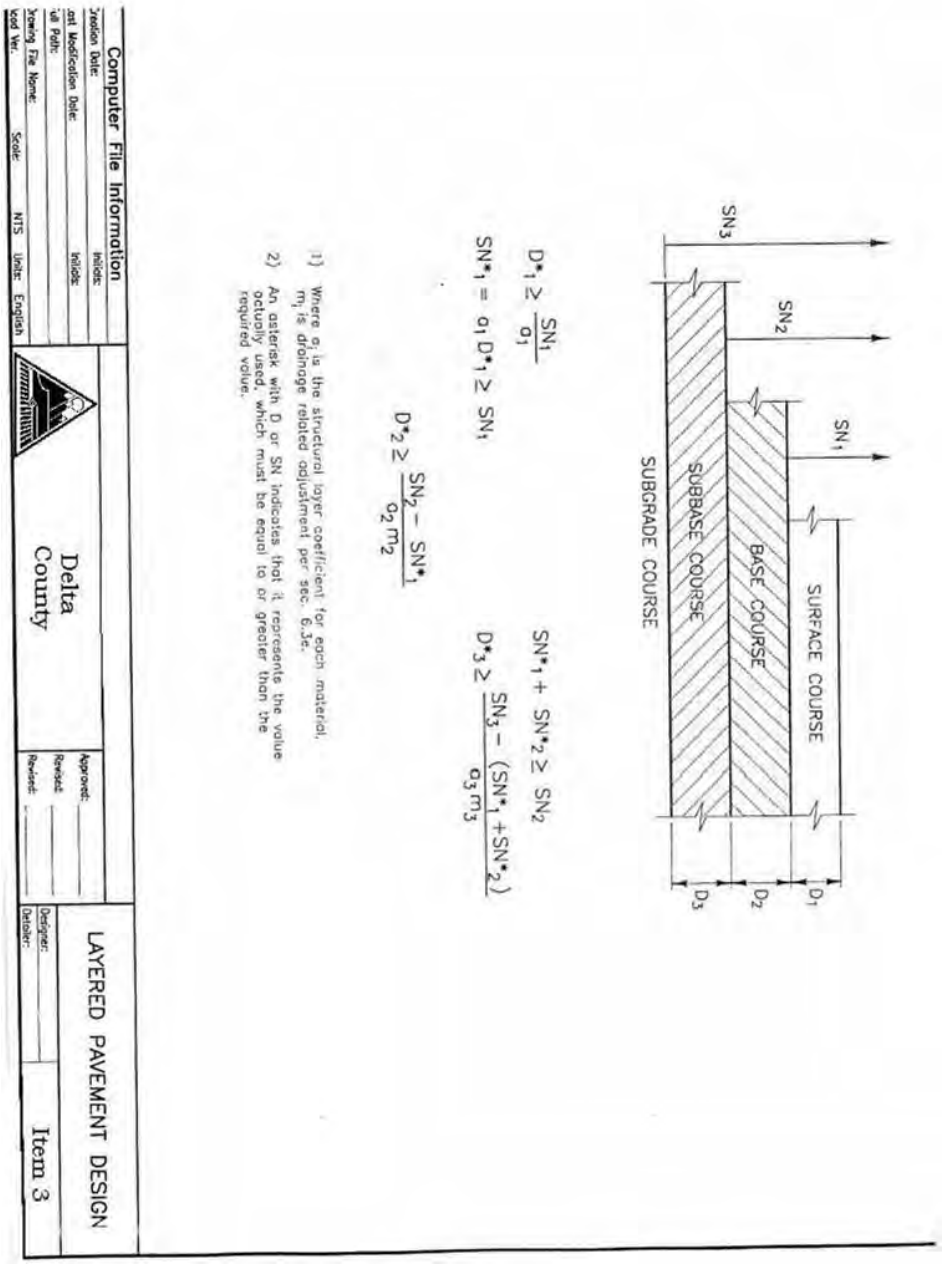
High-density polyethylene pipe – type "s" smooth interior wall, in conformance with AASHTO designation M 294. **(only in specifically approved applications)**

f. Aggregate base course material for the final surface of gravel roads will have a maximum liquid limit of 25, a plasticity index of 6 or less, and will consist of a crushed naturally occurring rock material (no slag) with at least 50 per cent of the material remaining on the number 4 sieve having at least two fractured faces. In addition, the material will meet the following gradation:

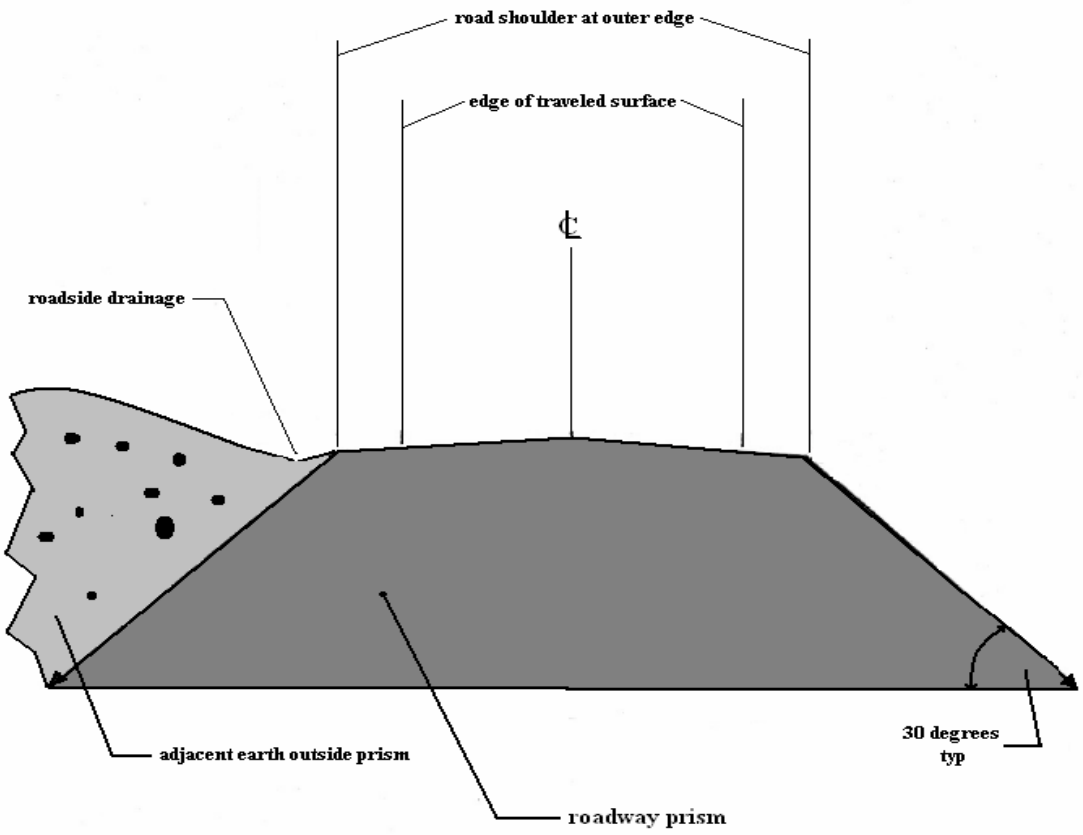
| Sieve Designation | % Passing |
|---|---|
| 1" | 100 |
| ½" | 75-85 |
| no.4 | 30-65 |
| no. 8 | 25-55 |
| no.200 | 12-18 |

All other CDOT specifications for aggregate base course not modified above will apply.

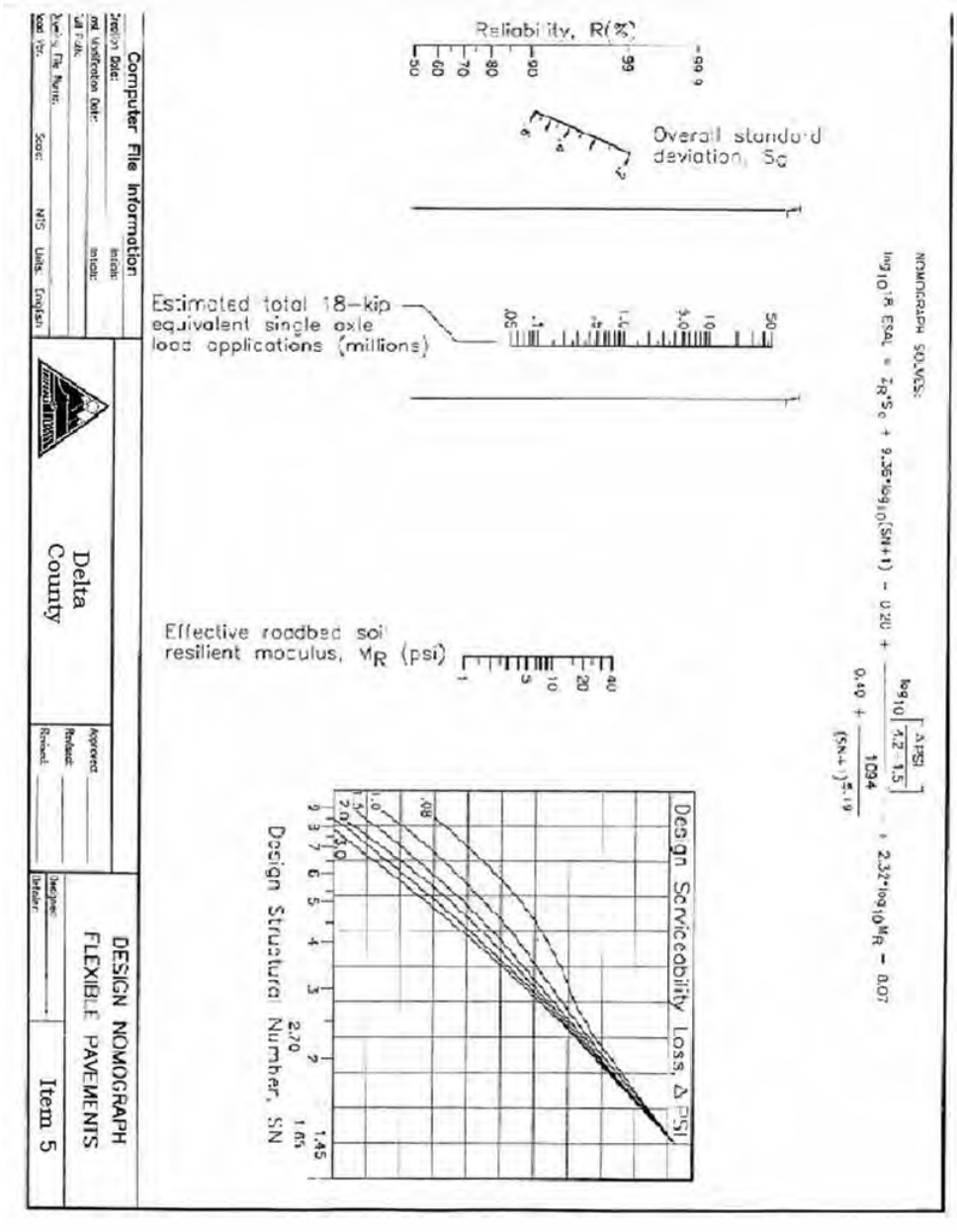
# Item 3
## Layered Pavement Design



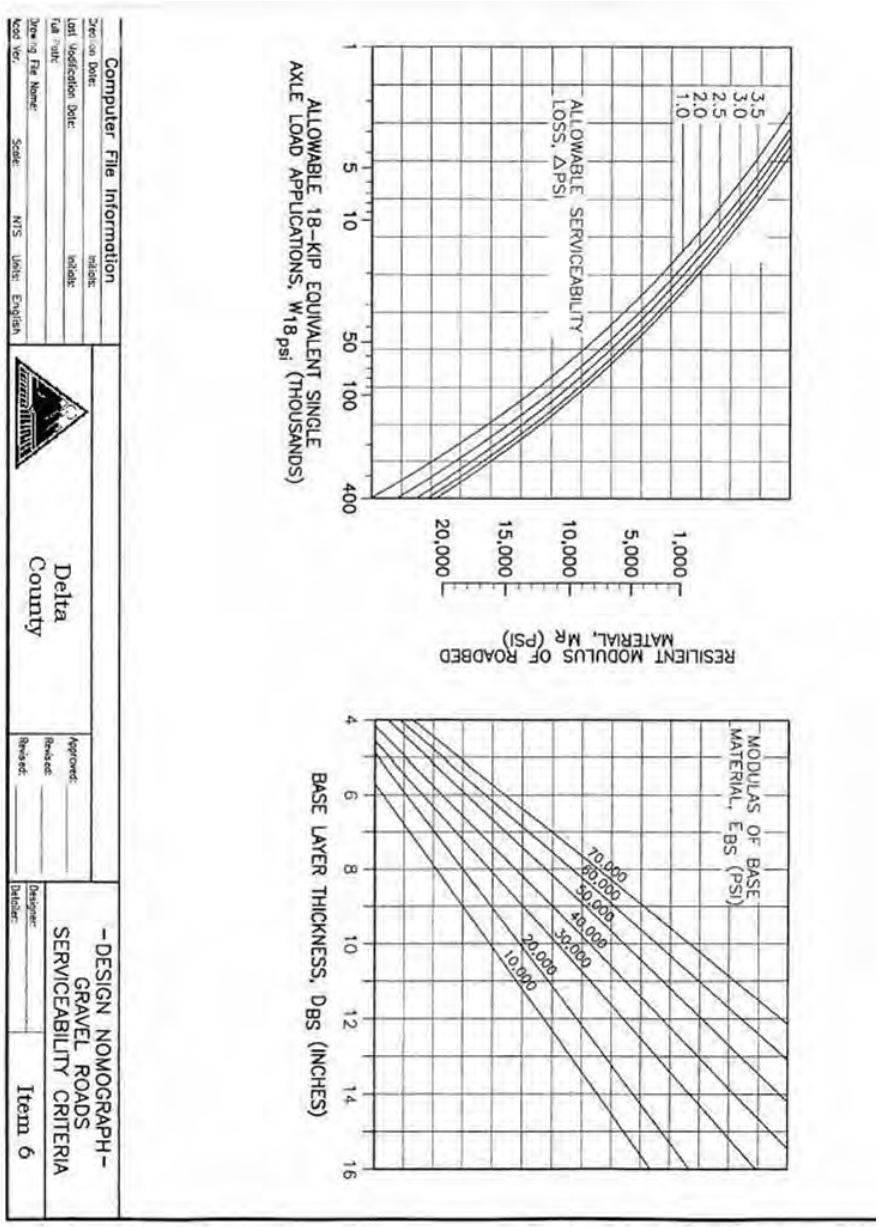
# Item 4
## Roadway Prism



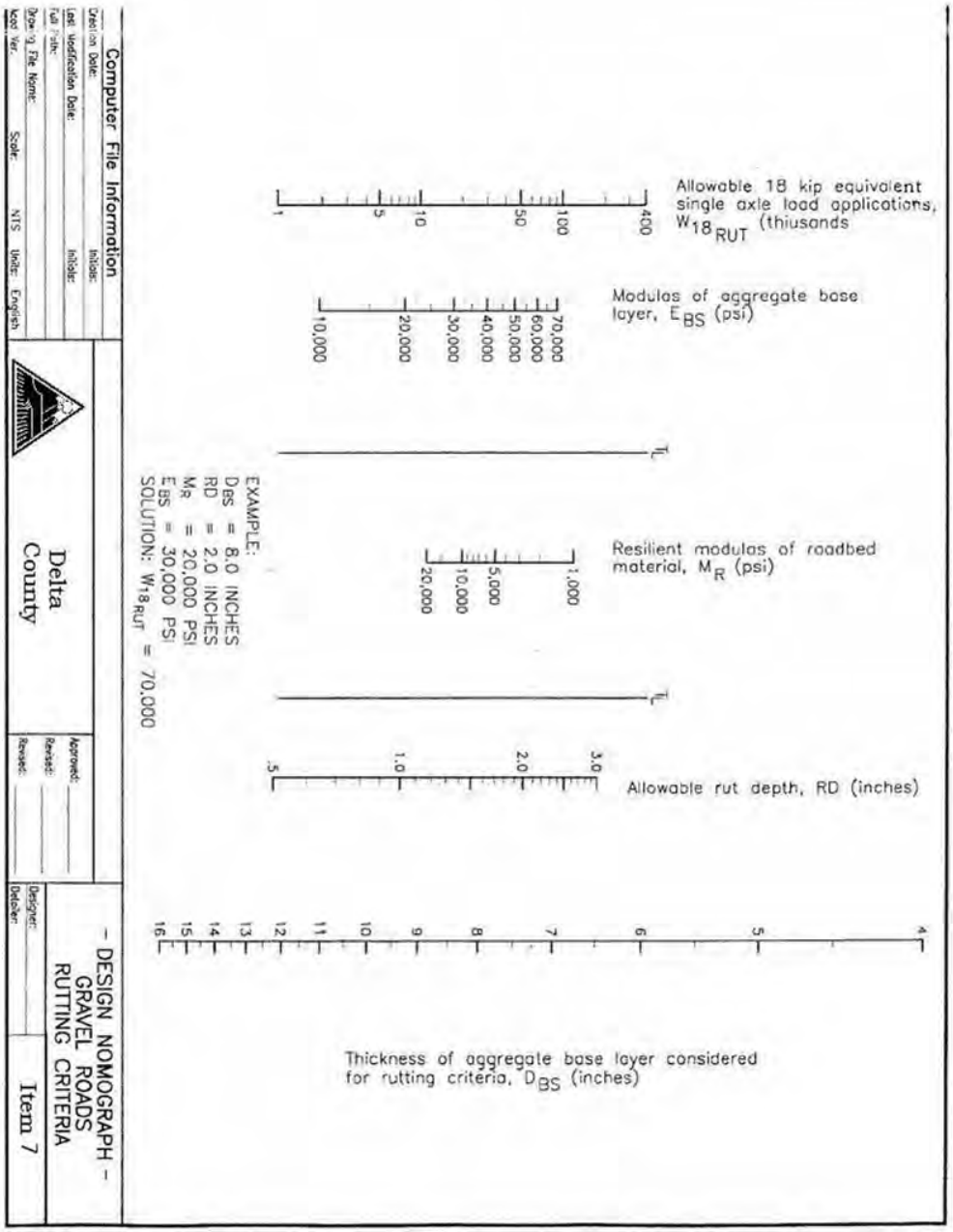
# Item 5
## Design Nomograph – Flexible Pavements



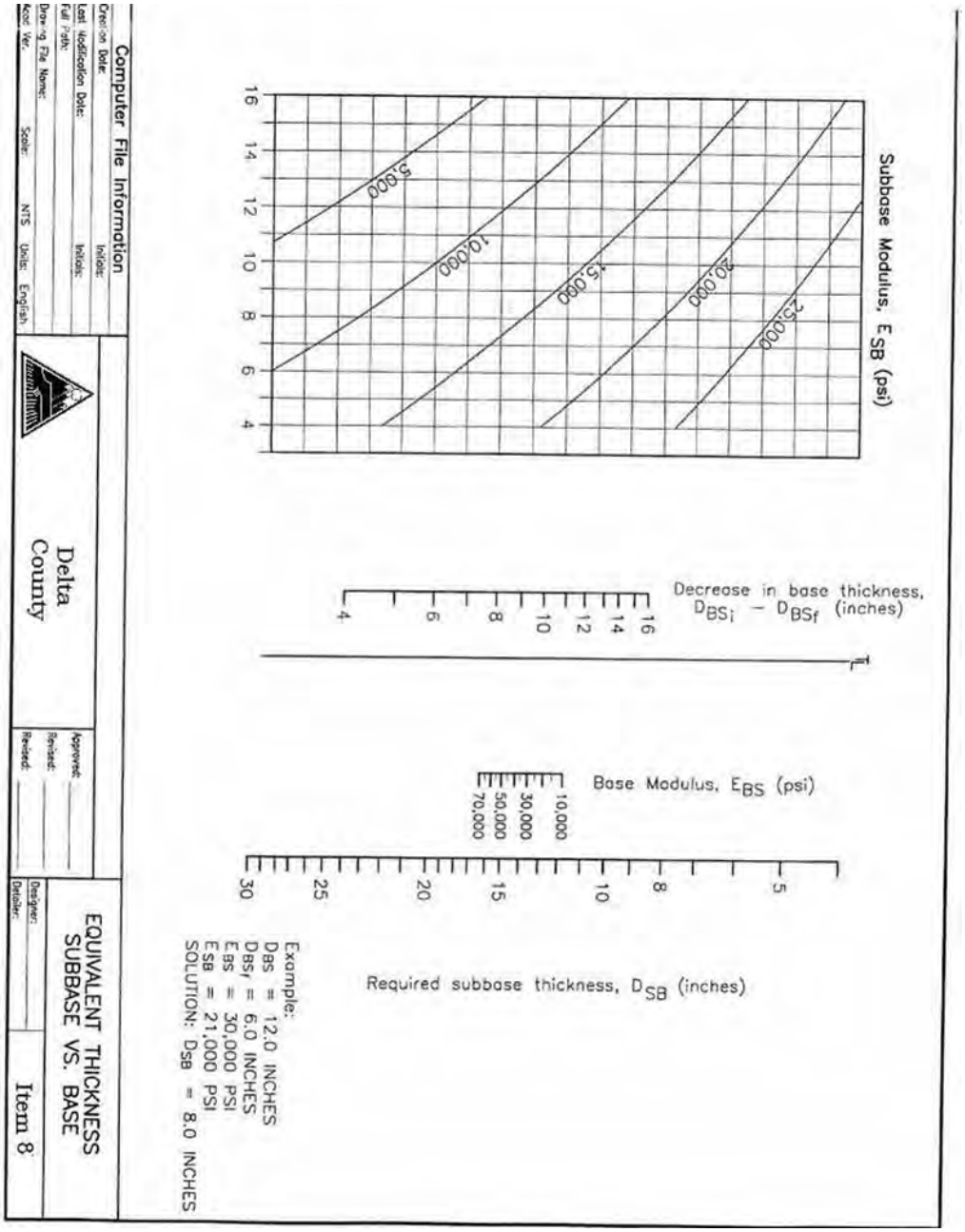
# Item 6
## Design Nomograph
## Gravel Roads Serviceability Criteria



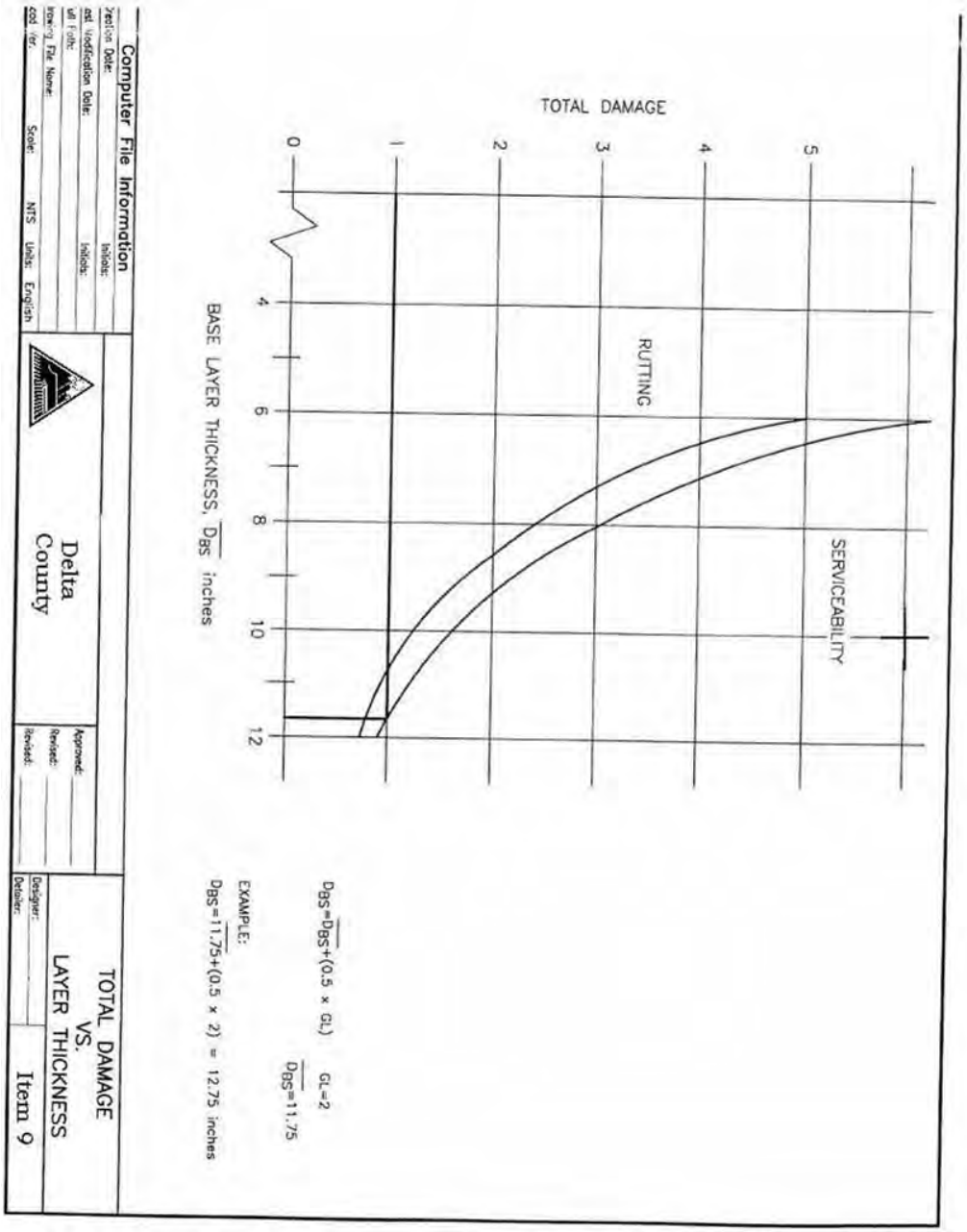
# Item 7
## Design Nomograph
## Gravel Roads Rutting Criteria



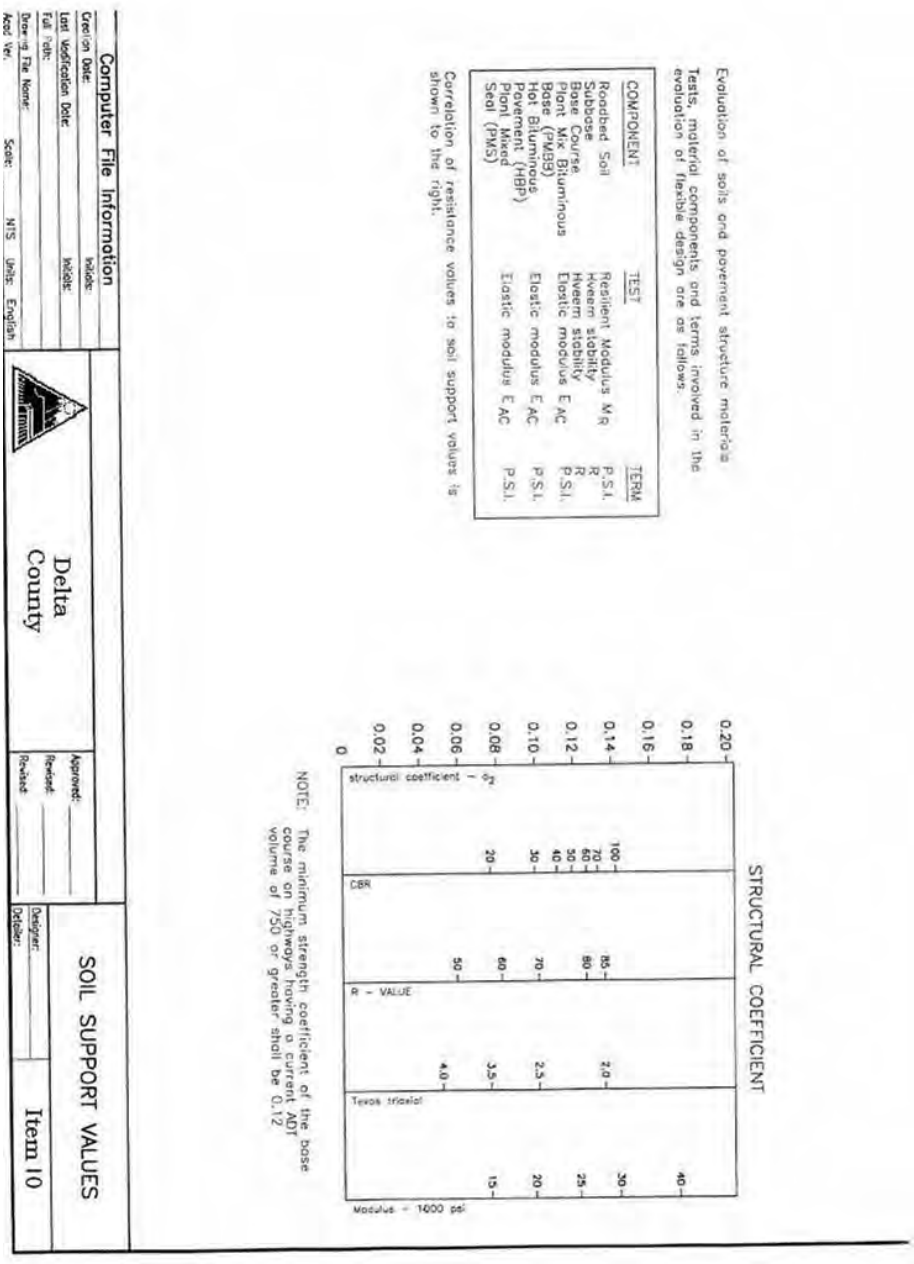
# Item 8
## Equivalent Thickness
## Subbase vs. Base



# Item 9
## Total Damage vs. Layer Thickness



# Item 10
## Soil Support Values



# Item 11
## Road Design Worksheet

| TRIAL BASE THICKNESS, $D_{BS}$ (INCHES)_____ | | | | SERVICEABILITY CRITERIA PSI = _____ | | RUTTING CRITERIA RD = _____ | |
|---|---|---|---|---|---|---|---|
| (1) SEASON (ROADBED MOISTURE CONDITION) | (2) ROADBED RESILIENT MODULUS $M_R$ (psi) | (3) BASE ELASTIC MODULUS EBS (psi) | (4) PROJECTED 18 – KIP ESAL TRAFFIC $W_{18}$ | (5) ALLOWABLE 18-KIP ESAL TRAFFIC $(W_{18})_{PSI}$ | (6) SEASONAL DAMAGE $W_{18}/(W_{18})_{PSI}$ | (7) ALLOWABLE 18 – KIP ESAL TRAFFIC $(W_{18})_{RUT}$ | (8) SEASONAL DAMAGE $W_{18}/(W_{18})_{RUT}$ |
| WINTER (FROZEN) | | | | | | | |
| SPRING/ THAW (SATURATED) | | | | | | | |
| SPRING/ FALL (WET) | | | | | | | |
| SUMMER (DRY) | | | | | | | |
| | | TOTAL TRAFFIC = | | TOTAL DAMAGE = | | TOTAL DAMAGE = | |

# Item 12
## Aggregate Classification Table

**Classification for Aggregate Base Course**

| Sieve Size | Mass Percent Passing Square Mesh Sieves | | | | | | |
|---|---|---|---|---|---|---|---|
| | LL not greater than 35 | | | LL not greater than 30 | | | |
| | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Class 6 | Class 7 |
| 100 mm (4") | | 100 | | | | | |
| 75 mm (3") | | 95-100 | | | | | |
| 63 mm (2½") | 100 | | | | | | |
| 50 mm (2") | 95-100 | | | 100 | | | |
| 37.5 mm (1½") | | | | 90-100 | 100 | | |
| 25.0 mm (1") | | | | | 95-100 | | 100 |
| 19.0 mm (¾") | | | | 50-90 | | 100 | |
| 4.75 mm (# 4) | 30-65 | | | 30-50 | 30-70 | 30-65 | |
| 4.75 mm (# 8) | | | | | | 25-55 | 20-85 |
| 4.75 µm (#200) | 3-15 | 3-15 | 20 max. | 3-12 | 3-15 | 3-12 | 5-15 |

NOTE: Class 3 material shall consist of bank or pit run material.
LL – liquid limit

# Item 13
## Road Cuts and Repairs

## Road Removal

Bituminous or concrete pavement removal will be accomplished by saw cutting or grinding clean, straight lines which should be perpendicular or parallel to the flow of traffic. All excavation of paved surfaces within thirty-six (36) inches of the edge of the pavement will require the removal and replacement of the pavement to the edge of the paved surface.

Excavation anywhere within the roadway prism, including areas outside the traveled way, will be required to be repaired as called for in the following Repairs section, with backfill and compaction requirements applying. See the Appendix for the cross section defining the roadway prism.

## Repairs

Excavation performed on gravel roads will be restored with compacted backfill and will include a road surface of Class 6 aggregate base course to a depth of four (4) inches minimum with proper compaction.

Gravel roads that have had a special surface treatment (for purposes of binding, dust abatement, etc) will have the surface treatment reintroduced as part of the repair. The treatment will be the same chemical composition as the original treatment unless otherwise approved for use by the County Engineer.

Proper compaction for the repair will be the same as for a new road as defined in the Structural Layers Design Details section of the Appendix. The road surface form and grade of the repaired area will conform to the original surface form and grade of the adjacent roadway area and will be required to maintain that form after the repair.

The County Engineer may require a testing plan for the repaired area showing proper construction and compaction if it is deemed appropriate. The County Engineer will be shown proof of acceptable flow-fill repair material composition when requested of the Permittee.

### Backfill

All road cuts will be repaired with full depth flow-fill or six (6) inch lifts of Class 6 aggregate with introduced moisture and compacted to ninety-five (95) percent AASHTO T 180. Pit Run or earth backfill may be allowed with pre-approval from the County Engineer in certain circumstances.

The minimum cement content for flow-fill is provided in the table below. Standard Readymix concrete backfill will not be allowable in the public right-of -way.

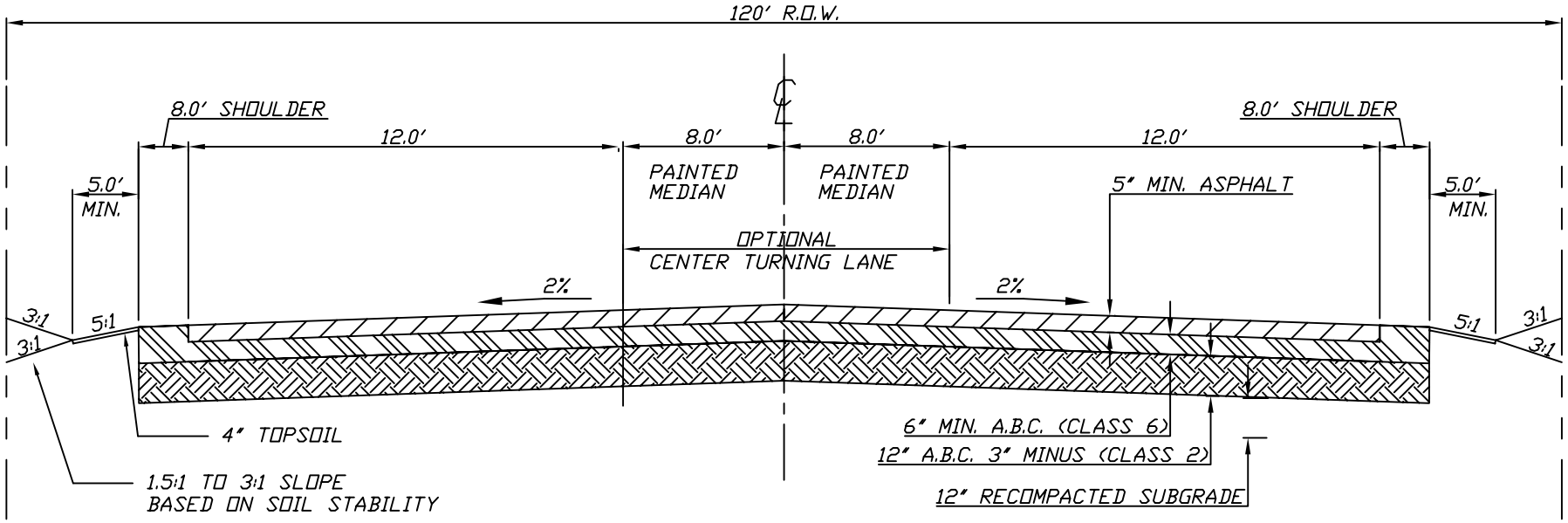
| | MINIMUM | MAXIMUM |
|---|---|---|
| **INGREDIENT** | **POUNDS/CUBIC YARD** | **POUNDS/CUBIC YARD** |
| Cement | 42 lbs (.47 sack) | 140 lbs (1.5 sacks) |
| Water | 325 (39 gallons or as needed) | 325 (39 gallons or as needed) |
| Coarse Aggregate (Size No. 57) | 1700 | 1700 |
| Sand (ASTM C-33) | 1845 | 1845 |

Flow-fill will have a maximum layer depth of three (3) feet. If the repair requires more than a three foot depth fill, the flow-fill can be completed in stages of maximum allowable depths with time allowed between fills for curing.

Flow-fill is prohibited as a temporary or permanent road surface. The excavation should be backfilled to the original surface level. After the flow-fill has had the proper cure time, the top surface of the flow-fill will be removed and the road surface will be placed to a depth and compaction as required for a new surface course for the original roadway material.

# Appendix 5

# Typical Roadway Cross Sections & Designs




TYPICAL CROSS SECTION

NOTES:
1) PAVEMENT DESIGN BY A PROFESSIONAL ENGINEER IS REQUIRED.
2) FULL DEPTH ASPHALT DESIGNS WILL NOT BE ALLOWED EXCEPT WITH THE SPECIFIC APPROVAL OF THE BOARD OF COUNTY COMMISSIONERS AND WILL NOT BE ALLOWED ON CLAY SUB-GRADE SOILS.
3) DEPTH OF A.B.C (CLASS 6) TO BE SUPPORTED BY PAVEMENT DESIGNS. DEPTH OVER 5" MAY BE CLASS 2 A.B.C.
4) ADDITIONAL RIGHT OF WAY MAY BE REQUIRED WHERE ACCELERATION/DECELERATION LANES OR TURN LANES ARE REQUIRED.

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
PRINCIPAL ARTERIAL
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REVISED | 1/28/09 |
| RJB | REDRAWN | 10/30/08 |

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DATE: 10/30/08
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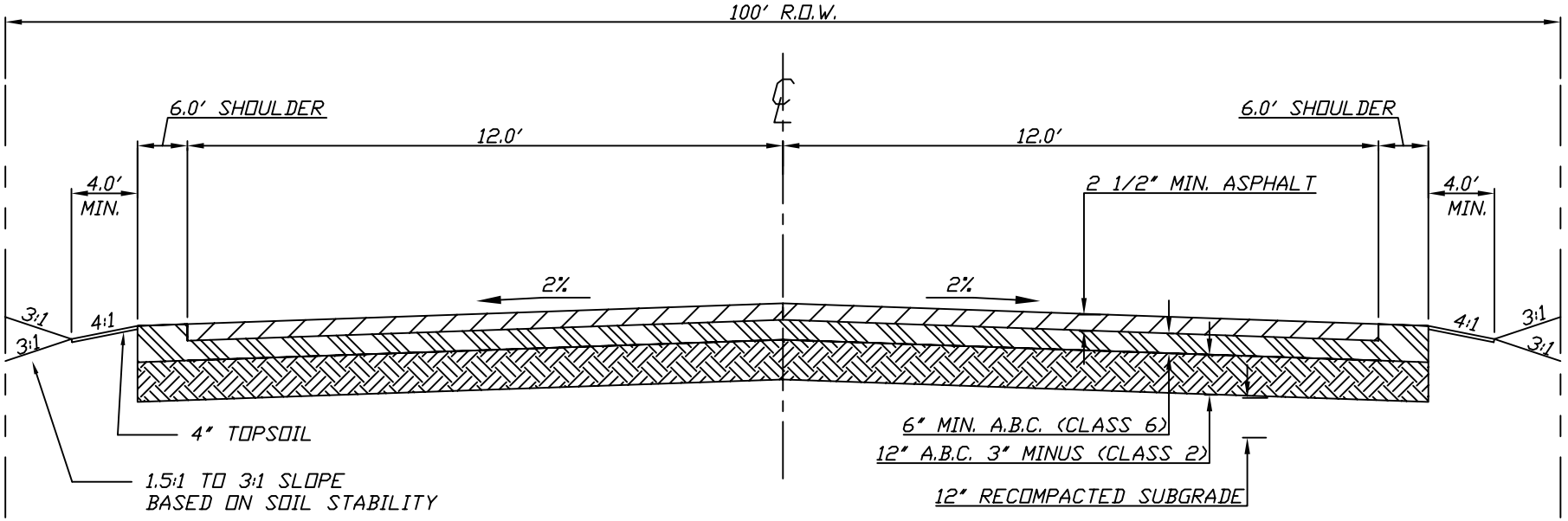
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 1

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DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
MINOR ARTERIAL
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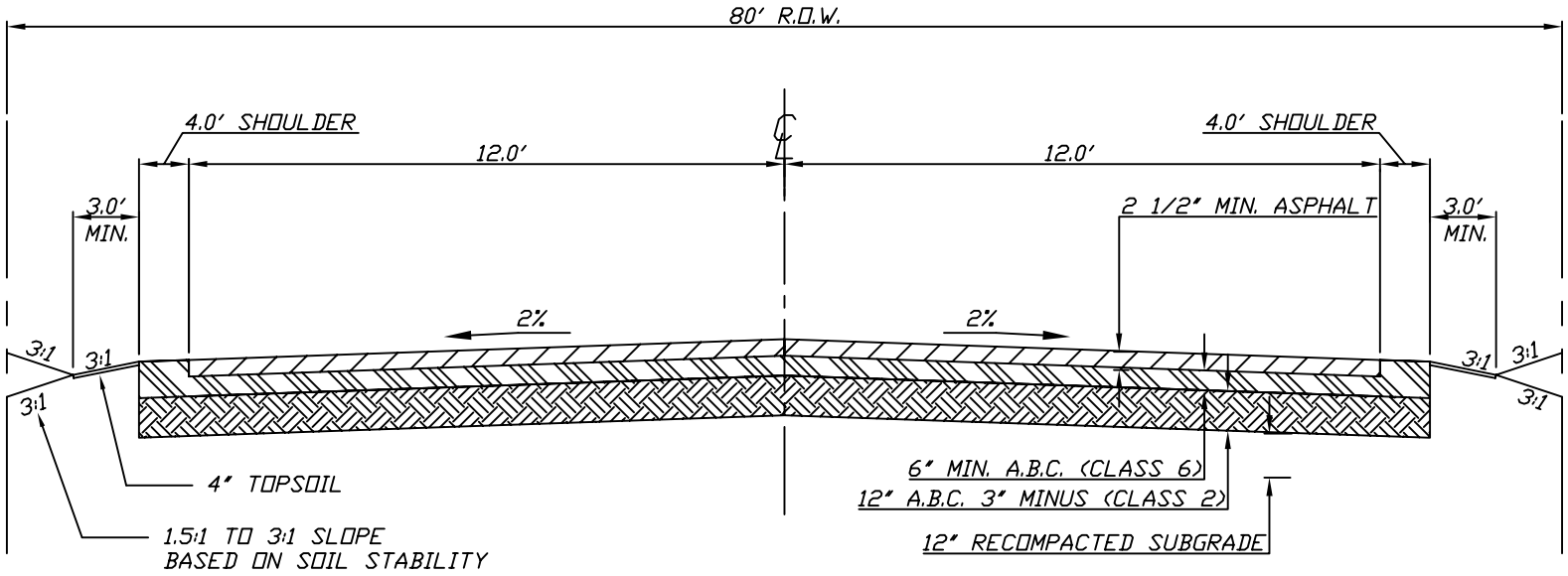
ITEM 2

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DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

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COLLECTOR
**DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS**

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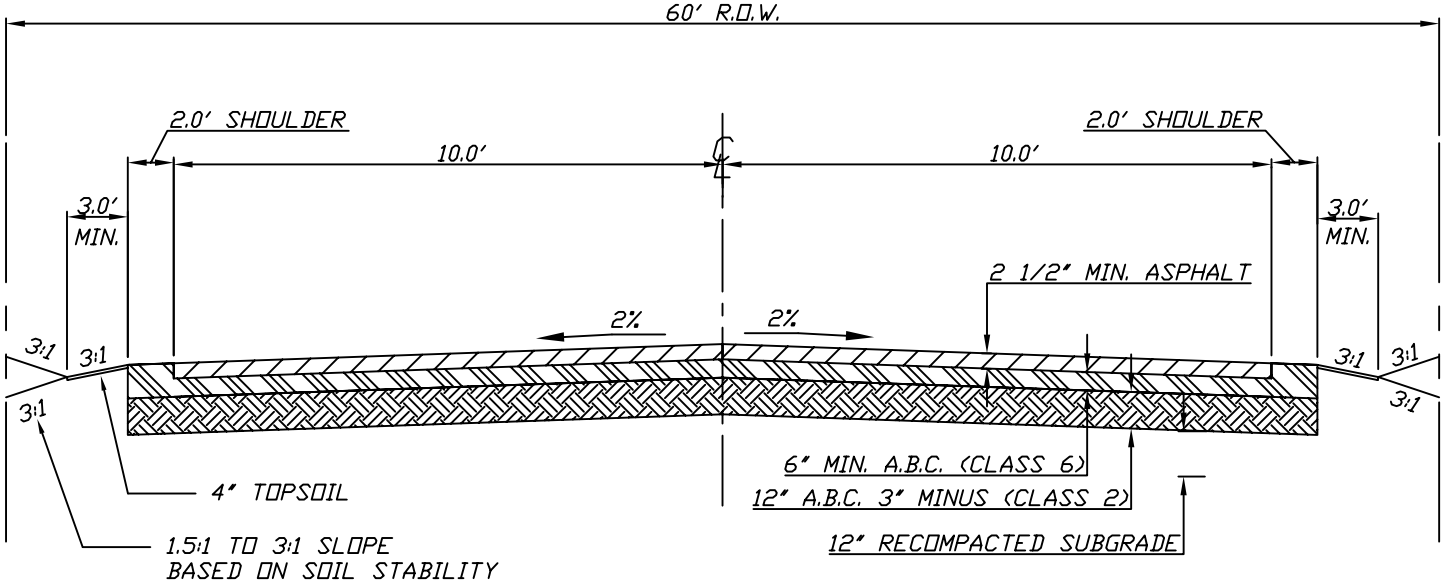
ITEM 3

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DELTA COUNTY
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501 PALMER STREET DELTA, CO 81416

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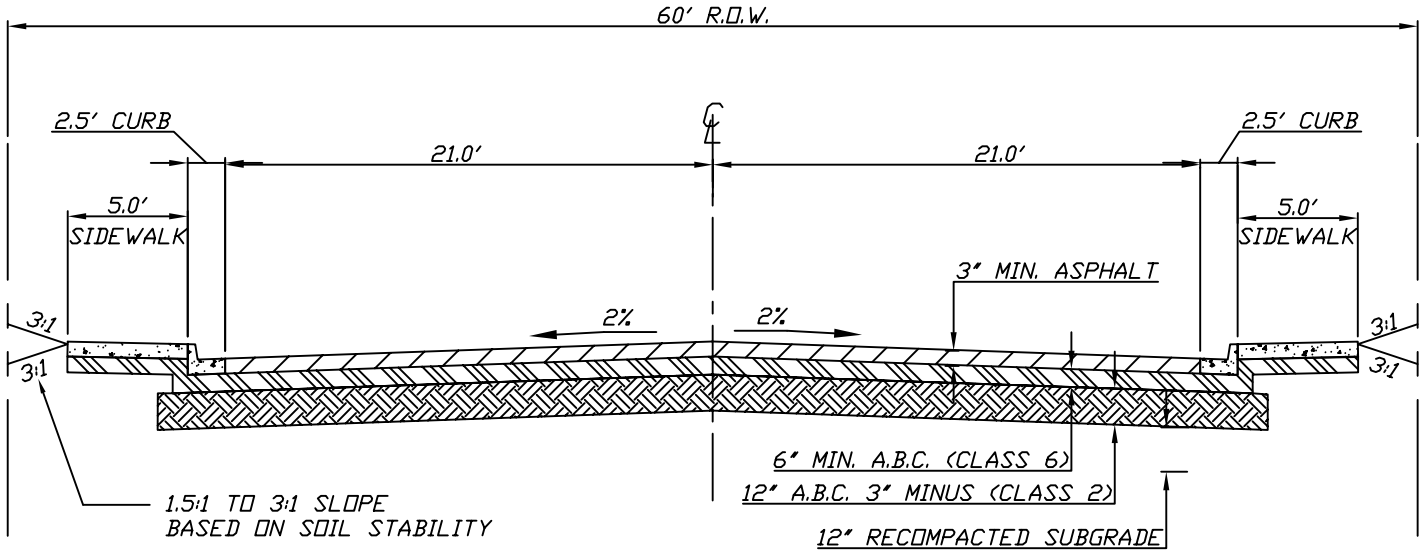
ITEM 4

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DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
LOCAL SERVICE, COMMERCIAL
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

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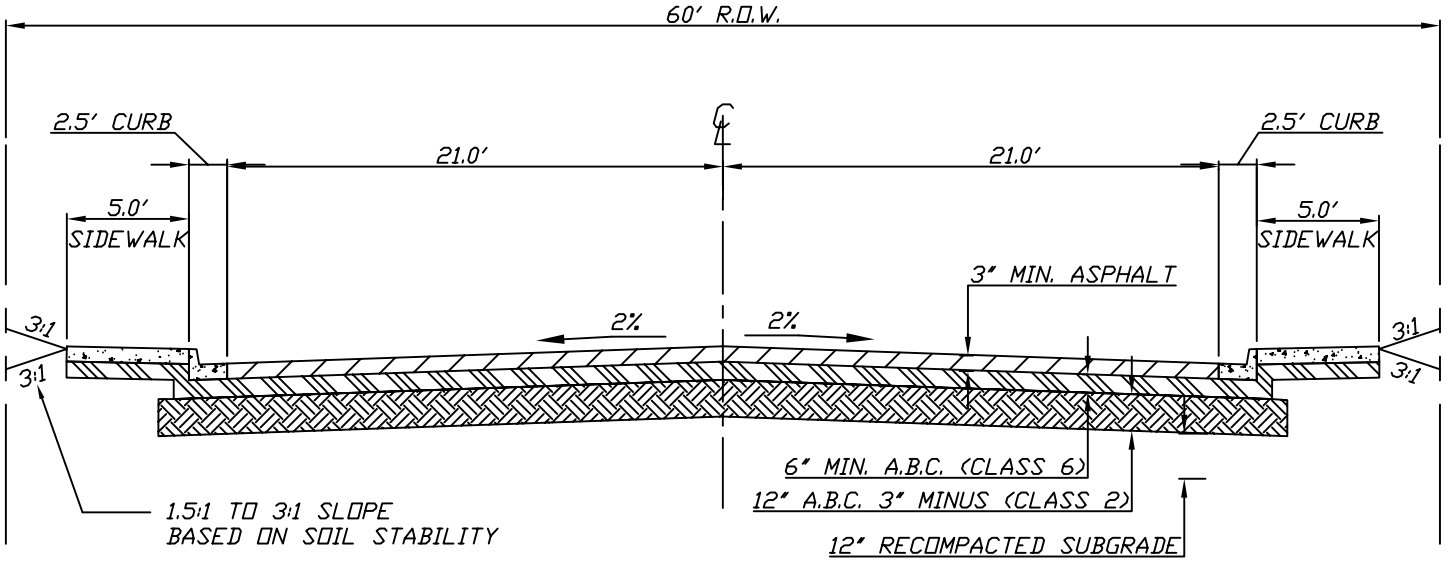
ITEM 5

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501 PALMER STREET DELTA, CO 81416

TITLE
LOCAL SERVICE, INDUSTRIAL
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

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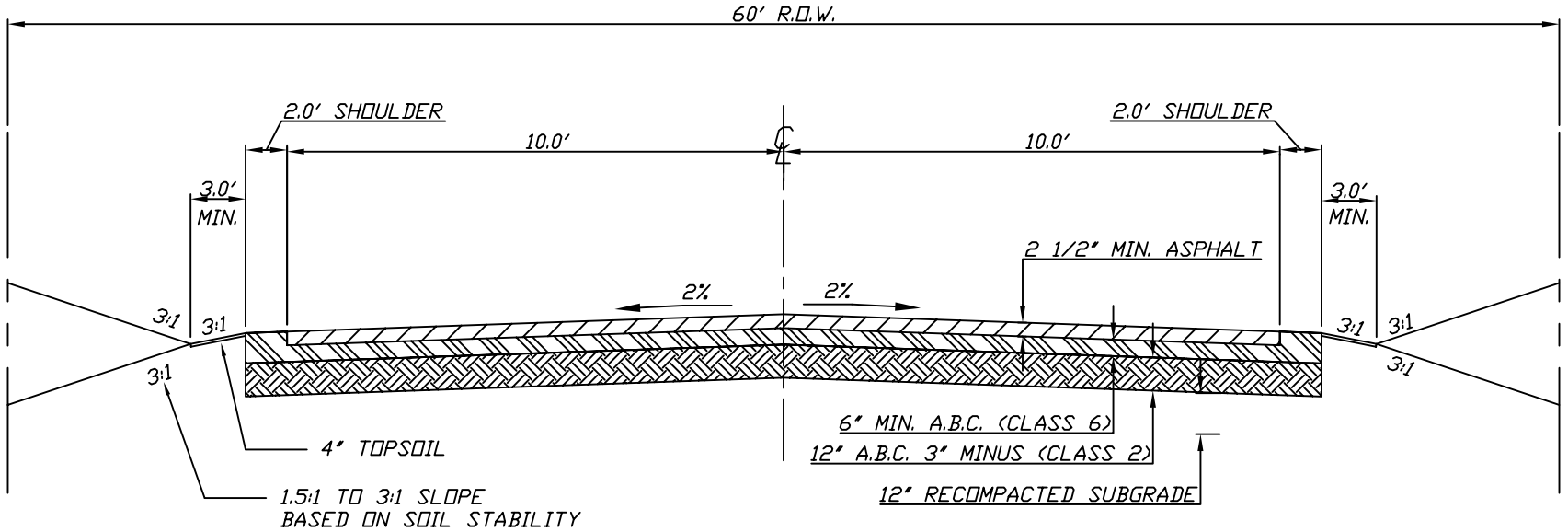


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DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
LOCAL SERVICE, RESIDENTIAL
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

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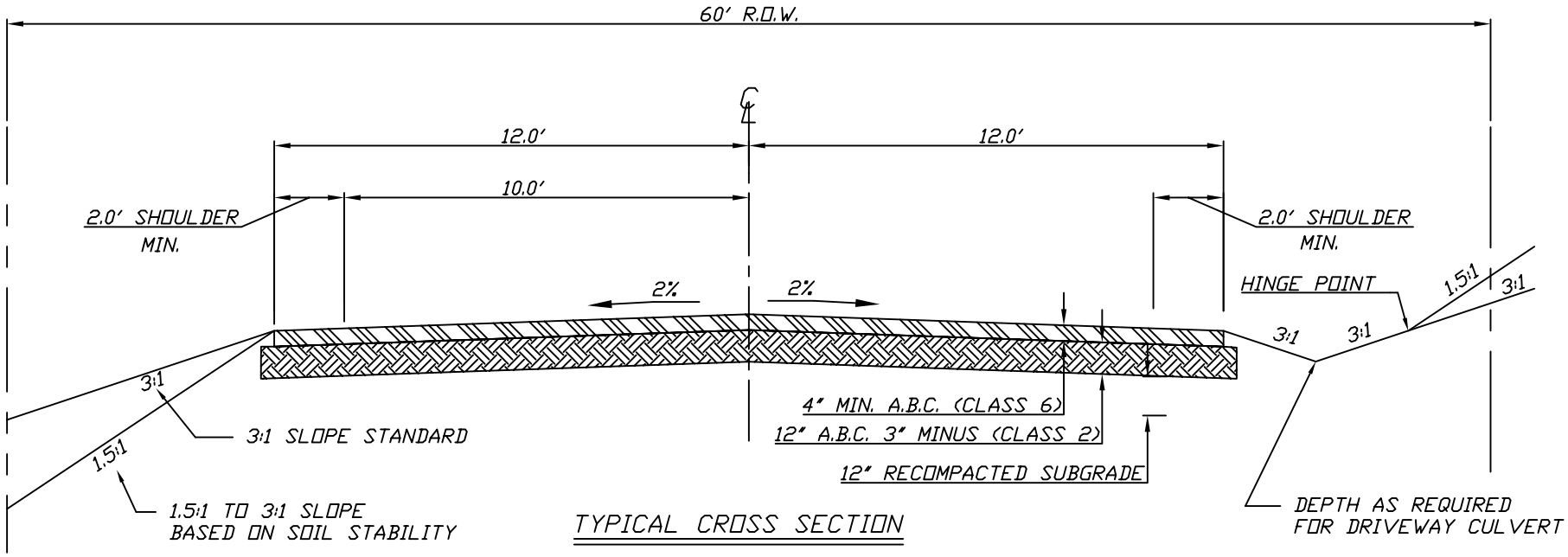
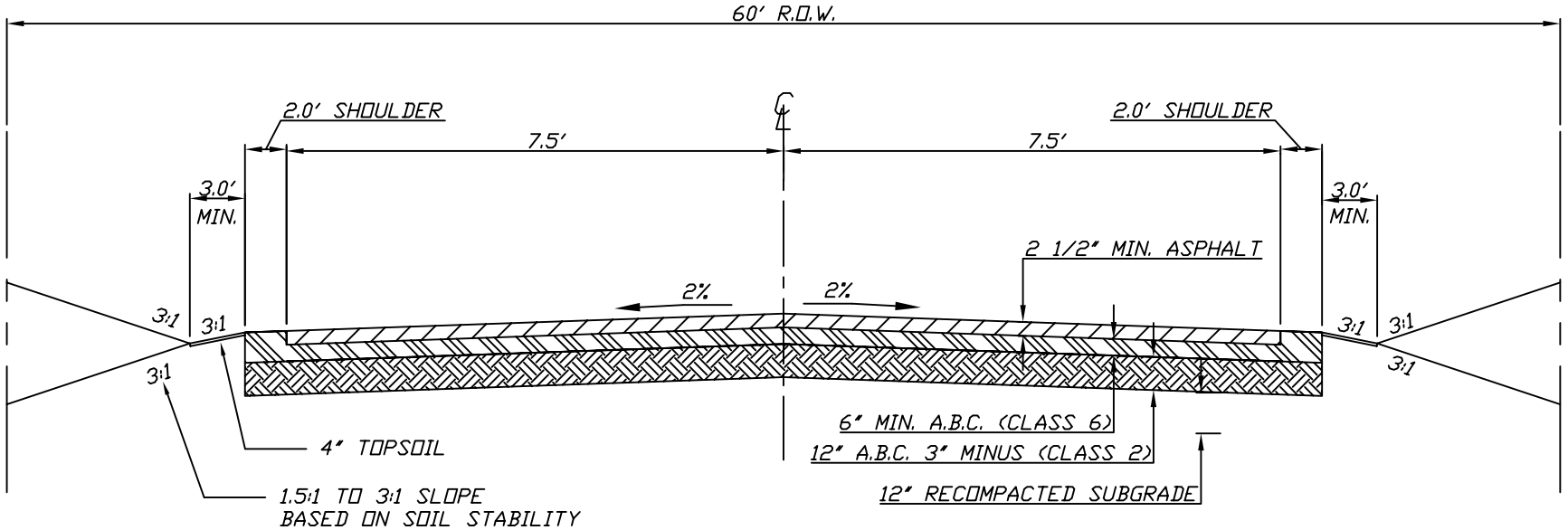
ITEM 7




TYPICAL CROSS SECTION

NOTES:
1) SUB-BASE THICKNESS MAY BE OTHER THAN INDICATED BASED ON THE RESULTS OF SOIL TESTING AND THE APPROVAL OF THE COUNTY ENGINEER.

| | | | | | |
|---|---|---|---|---|---|
| DELTA COUNTY<br>OFFICE OF THE COUNTY ENGINEER<br>501 PALMER STREET DELTA, CO 81416 | TITLE<br>LOCAL SERVICE, GRAVEL<br>DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS | BY | REVISION DESCRIPTION | DATE | SCALE: NOT TO SCALE<br>DESIGNED: DELTA COUNTY<br>DATE: 11/14/08<br>DRAWN: RJB<br>ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5 | ITEM 8 |
| | | RJB | REDRAWN | 11/14/08 | | |

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DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
LOCAL ACCESS
PUBLIC USE - PRIVATELY MAINTAINED
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

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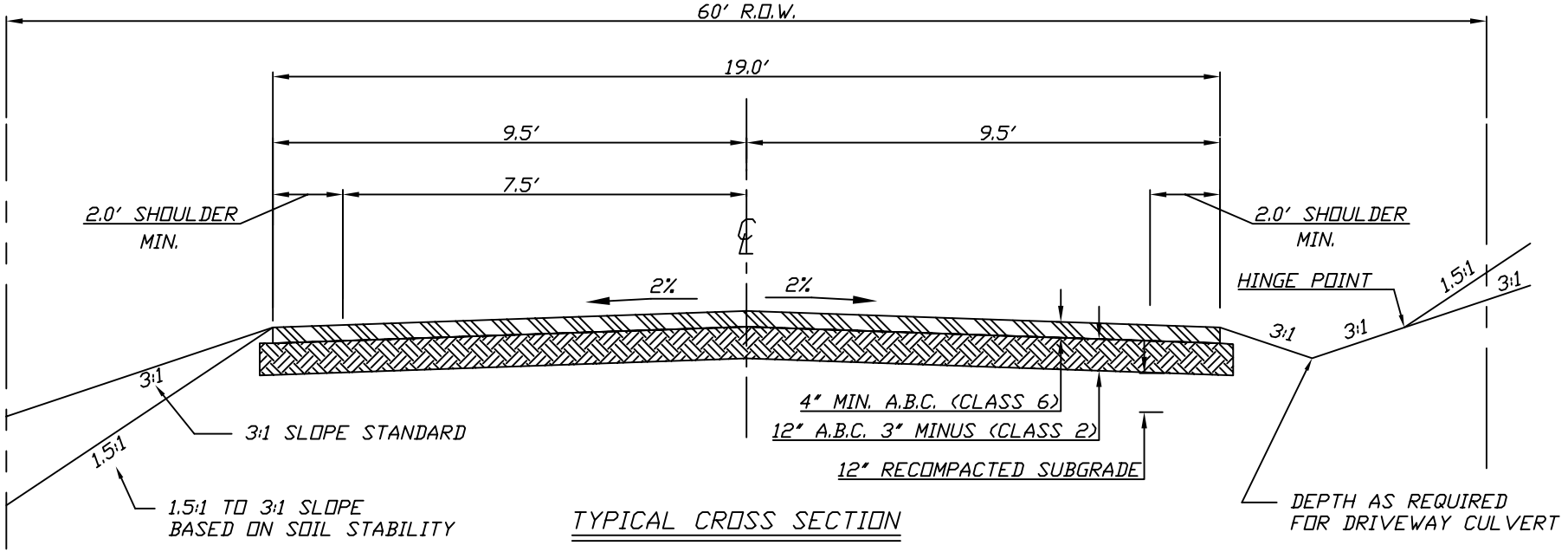
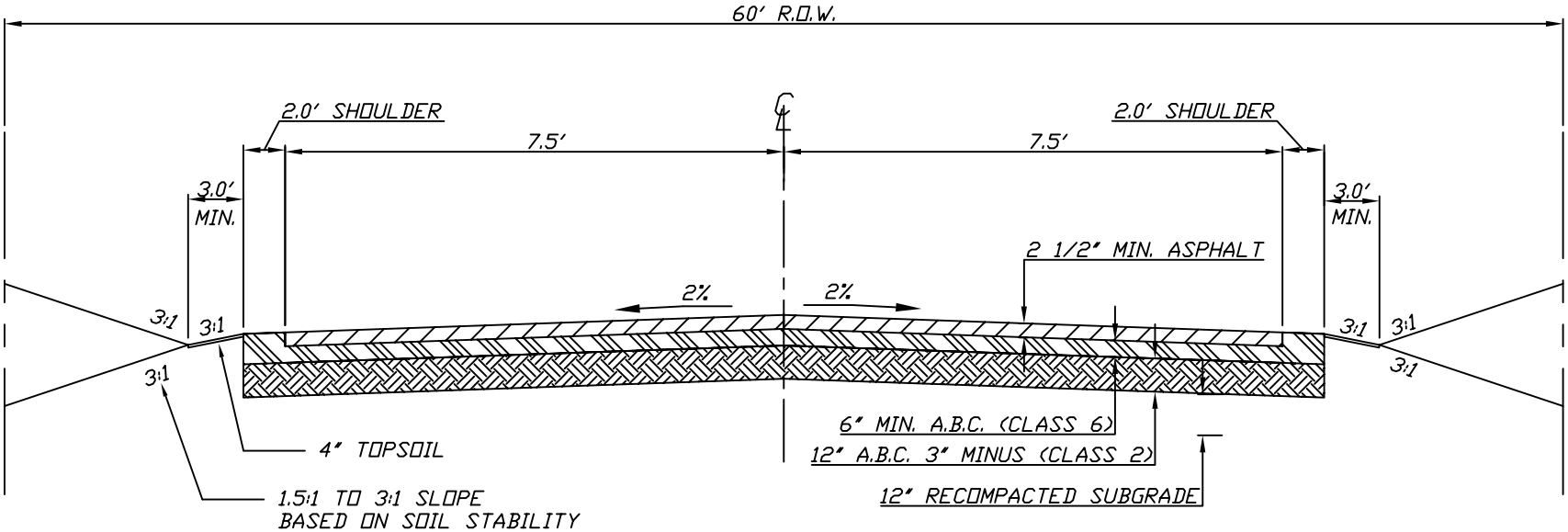
ITEM 9




TYPICAL CROSS SECTION

NOTES:
1) SUB-BASE THICKNESS MAY BE OTHER THAN INDICATED BASED ON THE RESULTS OF SOIL TESTING AND THE APPROVAL OF THE COUNTY ENGINEER.

| | | | | | |
|---|---|---|---|---|---|
| DELTA COUNTY<br>OFFICE OF THE COUNTY ENGINEER<br>501 PALMER STREET DELTA, CO 81416 | TITLE<br>LOCAL ACCESS, GRAVEL<br>PUBLIC USE – PRIVATELY MAINTAINED<br>DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS | BY | REVISION DESCRIPTION | DATE | SCALE: NOT TO SCALE<br>DESIGNED: DELTA COUNTY<br>DATE: 11/14/08<br>DRAWN: RJB<br>ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5 | ITEM 10 |
| | | RJB | REDRAWN | 11/14/08 | | |




TYPICAL CROSS SECTION

NOTES:
1) PAVEMENT DESIGN BY A PROFESSIONAL ENGINEER IS REQUIRED.
2) FULL DEPTH ASPHALT DESIGNS WILL NOT BE ALLOWED EXCEPT WITH THE SPECIFIC APPROVAL OF THE BOARD OF COUNTY COMMISSIONERS AND WILL NOT BE ALLOWED ON CLAY SUB-GRADE SOILS.
3) DEPTH OF A.B.C (CLASS 6) TO BE SUPPORTED BY PAVEMENT DESIGNS. DEPTH OVER 5" MAY BE CLASS 2 A.B.C.
4) ADDITIONAL RIGHT OF WAY MAY BE REQUIRED WHERE ACCELERATION/DECELERATION LANES OR TURN LANES ARE REQUIRED.

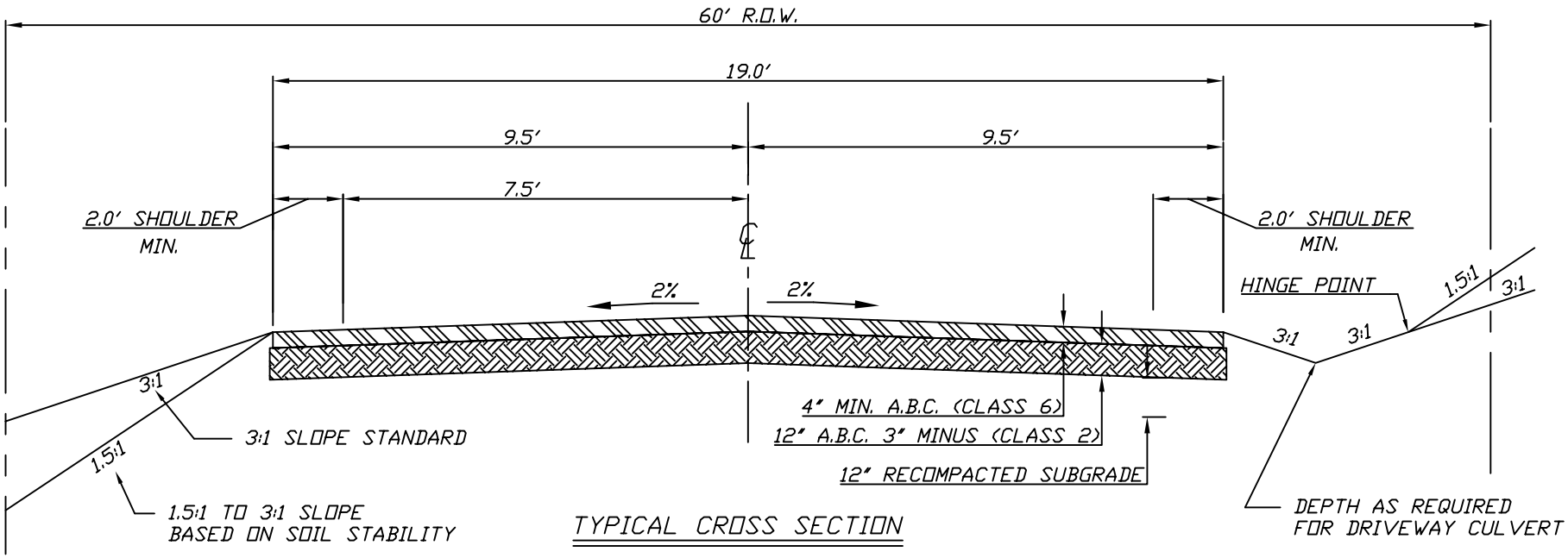
DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
LOCAL SERVICE
PUBLIC USE – PRIVATELY MAINTAINED
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REVISED | 1/29/09 |
| RJB | REDRAWN | 11/17/08 |

SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 11/17/08
DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

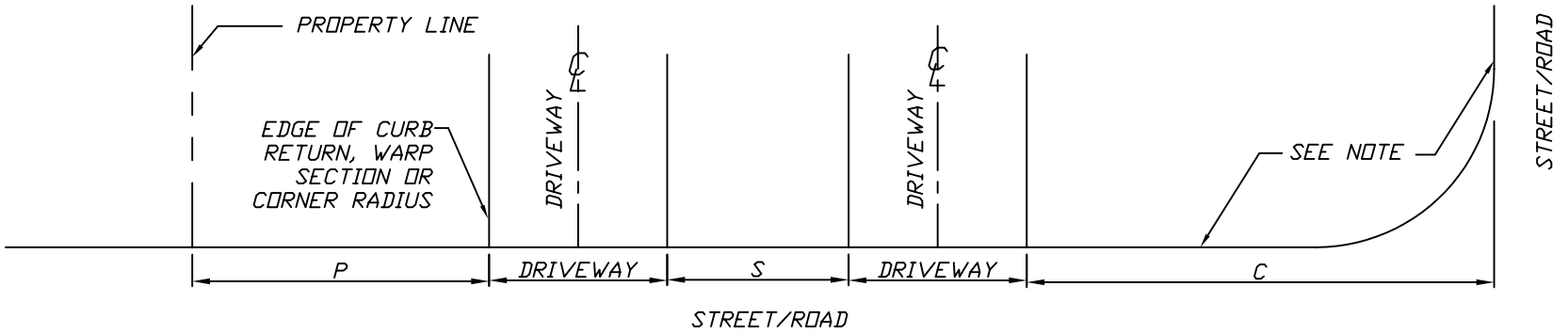
ITEM 11




TYPICAL CROSS SECTION

NOTES:
1) SUB-BASE THICKNESS MAY BE OTHER THAN INDICATED BASED ON THE RESULTS OF SOIL TESTING AND THE APPROVAL OF THE COUNTY ENGINEER.

| | | | | | |
|---|---|---|---|---|---|
| DELTA COUNTY<br>OFFICE OF THE COUNTY ENGINEER<br>501 PALMER STREET DELTA, CO 81416 | TITLE<br>LOCAL SERVICE, GRAVEL<br>PUBLIC USE – PRIVATELY MAINTAINED<br>DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS | BY | REVISION DESCRIPTION | DATE | SCALE: NOT TO SCALE<br>DESIGNED: DELTA COUNTY<br>DATE: 11/14/08<br>DRAWN: RJB<br>ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5 |
| | | RJB | REDRAWN | 11/14/08 | ITEM 12 |




NOTE: FLOWLINE OF CURB/GUTTER OR EDGE OF ASSPHALT IF CURB/GUTTER DOES NOT EXIST OR EDGE OF SHOULDER IF ASPHALT DOES NOT EXIST.

| RESIDENTIAL DRIVEWAYS | FIGURE REFERENCE | DIMENSIONS |
|---|---|---|
| FROM PROPERTY LINES | P | 5′ * |
| FROM STREET/ROAD INTERSECTION, NON-ARTERIAL | C | 50′ |
| FROM STREET/ROAD INTERSECTION, ARTERIAL | C | 100′ |
| BETWEEN DRIVEWAYS | | |
| ON LOCALS | S | 10′ |
| ON COLLECTORS | S | 200′ |
| ON ARTERIALS | S | 325′ |
| NON-RESIDENTIAL DRIVEWAYS ON LOCALS | | |
| FROM PROPERTY LINES | P | 5′ * |
| FROM ARTERIAL STREET INTERSECTIONS | C | 200′ ** |
| FROM COLLECTOR STREET INTERSECTIONS | C | 100′ ** |
| FROM LOCAL STREET INTERSECTIONS | C | 50′ ** |
| BETWEEN DRIVEWAYS | S | 100′ ** |
| NON-RESIDENTIAL DRIVEWAYS ON COLLECTORS | | |
| FROM PROPERTY LINES | P | 5′ * |
| FROM ARTERIAL STREET INTERSECTIONS | C | 300′ ** |
| FROM COLLECTOR STREET INTERSECTIONS | C | 200′ ** |
| FROM LOCAL STREET INTERSECTIONS | C | 125′ ** |
| BETWEEN DRIVEWAYS | S | 150′ ** |
| NON-RESIDENTIAL DRIVEWAYS ON COLLECTORS | | |
| FROM PROPERTY LINES | P | 5′ * |
| FROM STREET INTERSECTIONS | C | 500′ *** |
| BETWEEN DRIVEWAYS | S | 325′ ** |

* EXCEPT AT SHARED LOCATIONS.

** THE C AND S DIMENSIONSMAY BE REDUCED IF APPROVED BY THE BOARD OF COUNTY COMMISSIONERS DUE TO THE EXISTENCE OF LIMITING FACTORS. SELECTED TURNING MOVEMENTS MAY BE PROHIBITED.

*** IF THE PROPOSED DRIVEWAY IS RESTRICTED TO RIGHT TURN MOVEMENTS OR IF IT IS NOT ALIGNED WITH AN EXISTING OR PLANNED LEFT TURN LANE THE C DIMENSION MAY BE REDUCED IF APPROVED BY THE BOARD OF COUNTY COMMISSIONERS DUE TO THE EXISTANCE OF LIMITING FACTORS. IF SIGNALIZATION IS PROPOSED THE MINIMUM C DISTANCE SHALL BE INCREASED TO 650 FEET UNLESS OTHERWISE APPROVED.

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE

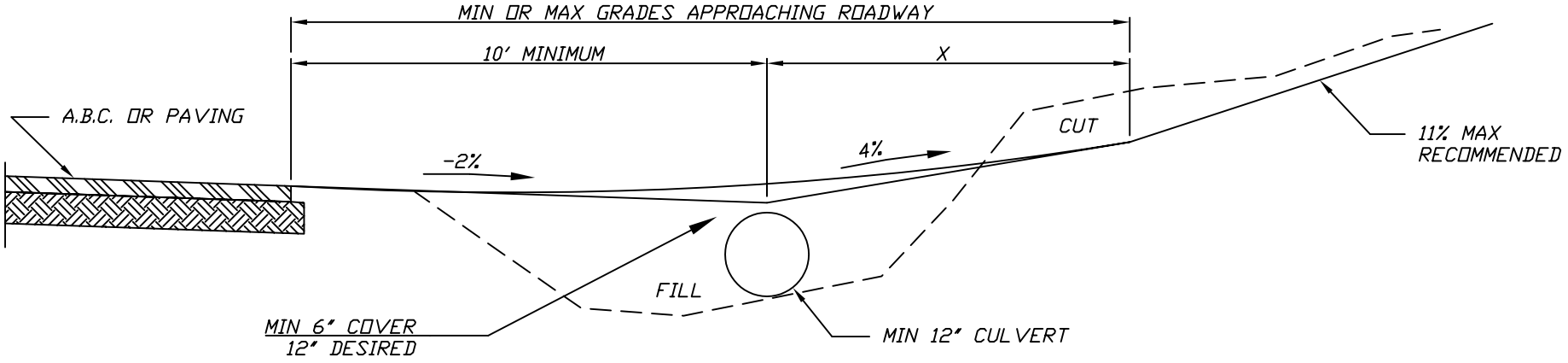
# DRIVEWAY SPACING

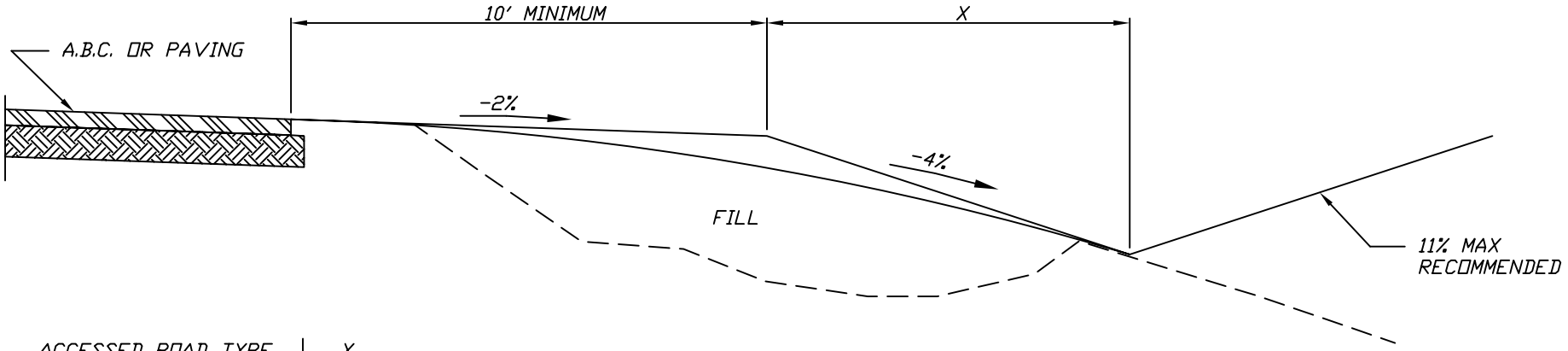
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/17/08 |

SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 11/17/08 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 13




| ACCESSED ROAD TYPE | X |
|---|---|
| LOCAL SERVICE | 10' |
| LOCAL ACCESS | 20' |
| COLLECTOR | 20' |
| ARTERIAL | 30' |

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

**TITLE**

# DRIVEWAY PROFILES

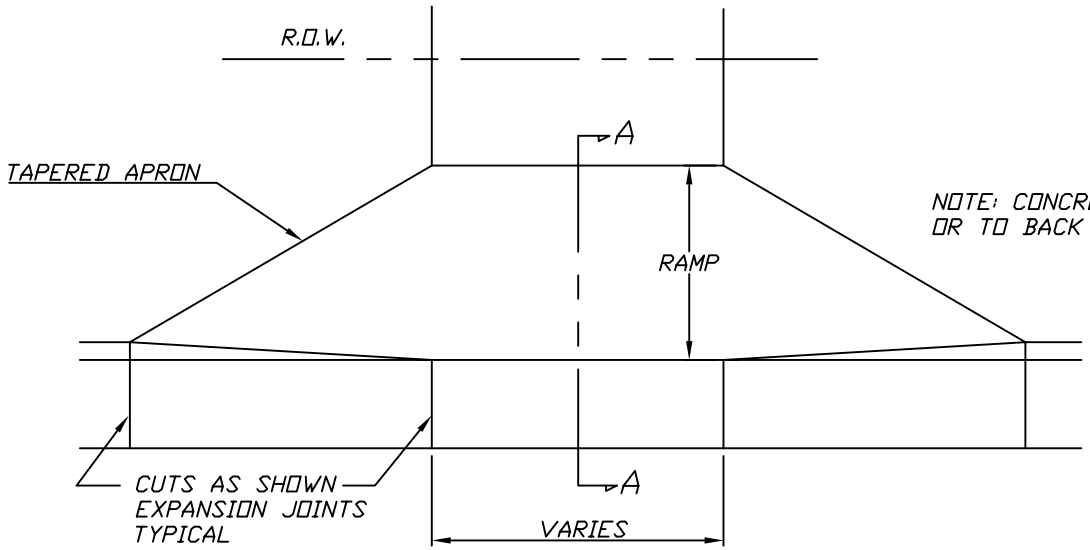
**PUBLIC USE – PRIVATELY MAINTAINED**

**DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS**

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/17/08 |

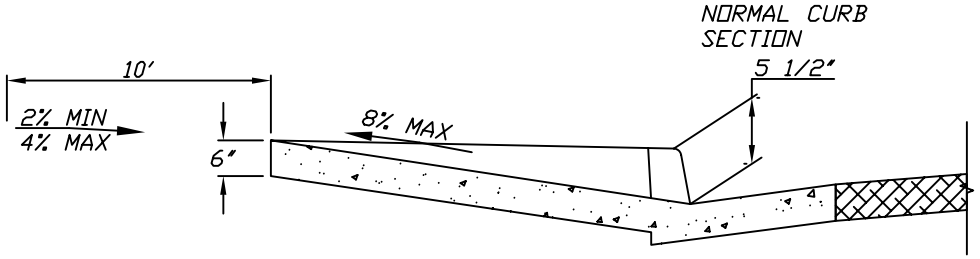
SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 11/17/08 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 14

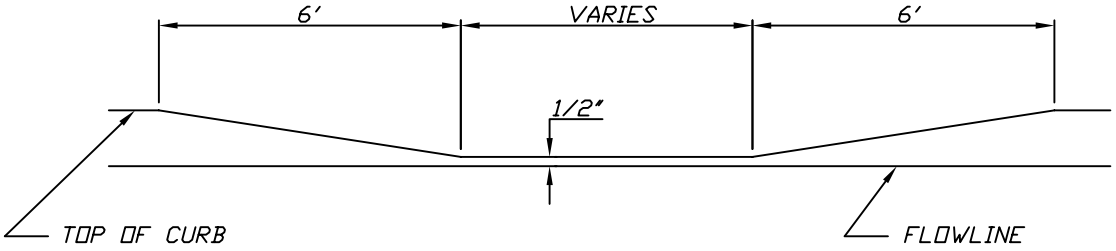



PLAN VIEW

NOTE: CONCRETE RAMP SHALL EXTEND 4' TO 6'
OR TO BACK OF SIDEWALK




SECTION A-A




TYPICAL CURB CUT SECTION

| URBAN DRIVEWAY WIDTHS | | |
|---|---|---|
| | MIN. | MAX. |
| RESIDENTIAL | 12' | 20' |
| COMMERCIAL | 20' | 30' |

DRIVES OVER 30' MAY REQUIRE CONSTRUCTION AS A ROAD APPROACH WITH CURB RETURNS AND CROSS PAN.


DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416


TITLE
URBAN DRIVEWAYS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

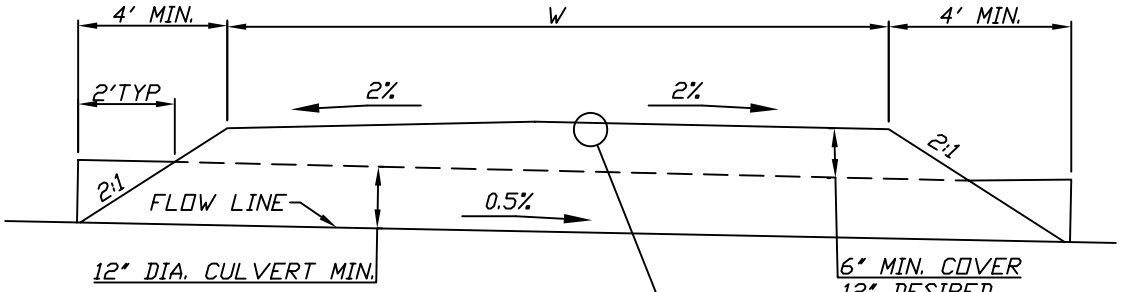
| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/18/08 |

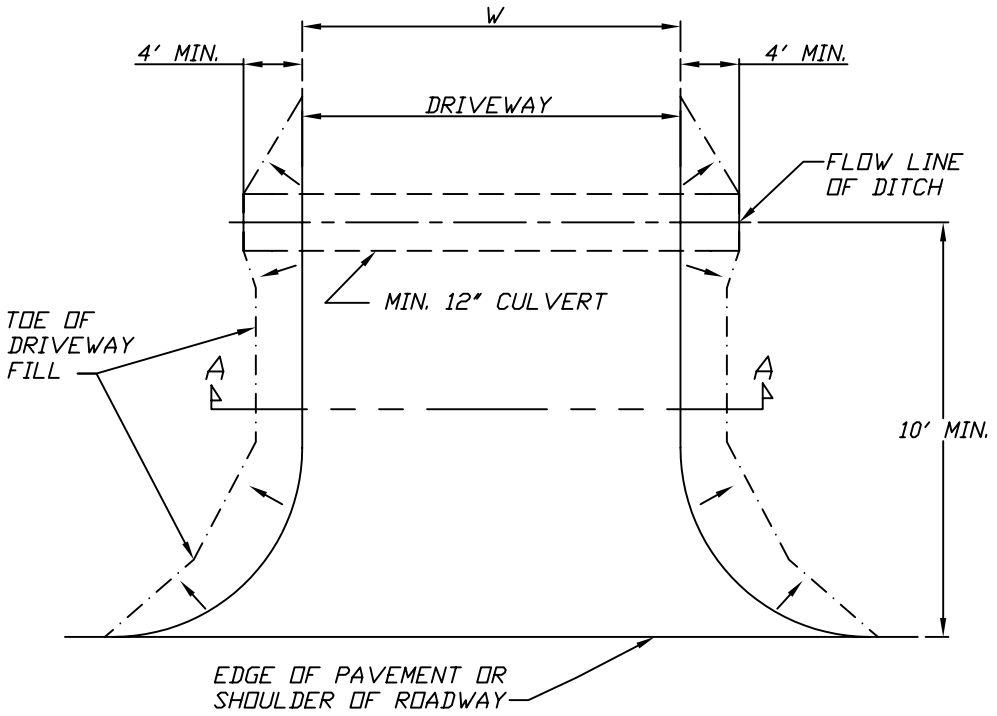
SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 11/18/08 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

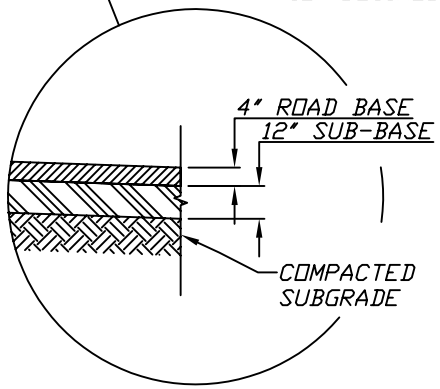
ITEM 15

## RURAL DRIVEWAY WIDTHS

| USE | W MIN. | W MAX. |
|---|---|---|
| RESIDENTIAL | 12′ | 18′ |
| SHARED ACCESS | 16′ | 24′ |
| MULTI-FAMILY RESIDENCE | 16′ | 24′ |
| COMMERCIAL | 16′ | 24′ |
| INDUSTRIAL | 24′ | 30′ |
| AGRICULTURAL | 16′ | 30′ |




NOTES:
1. FOR DRIVEWAYS ALONG GRAVEL ROADWAYS, THE DRIVEWAY SHALL BE CAPPED FROM THE ROADWAY EDGE TO THE PROPERTY LINE WITH CLASS 6 A.B.C. MIN. 6″ DEPTH.

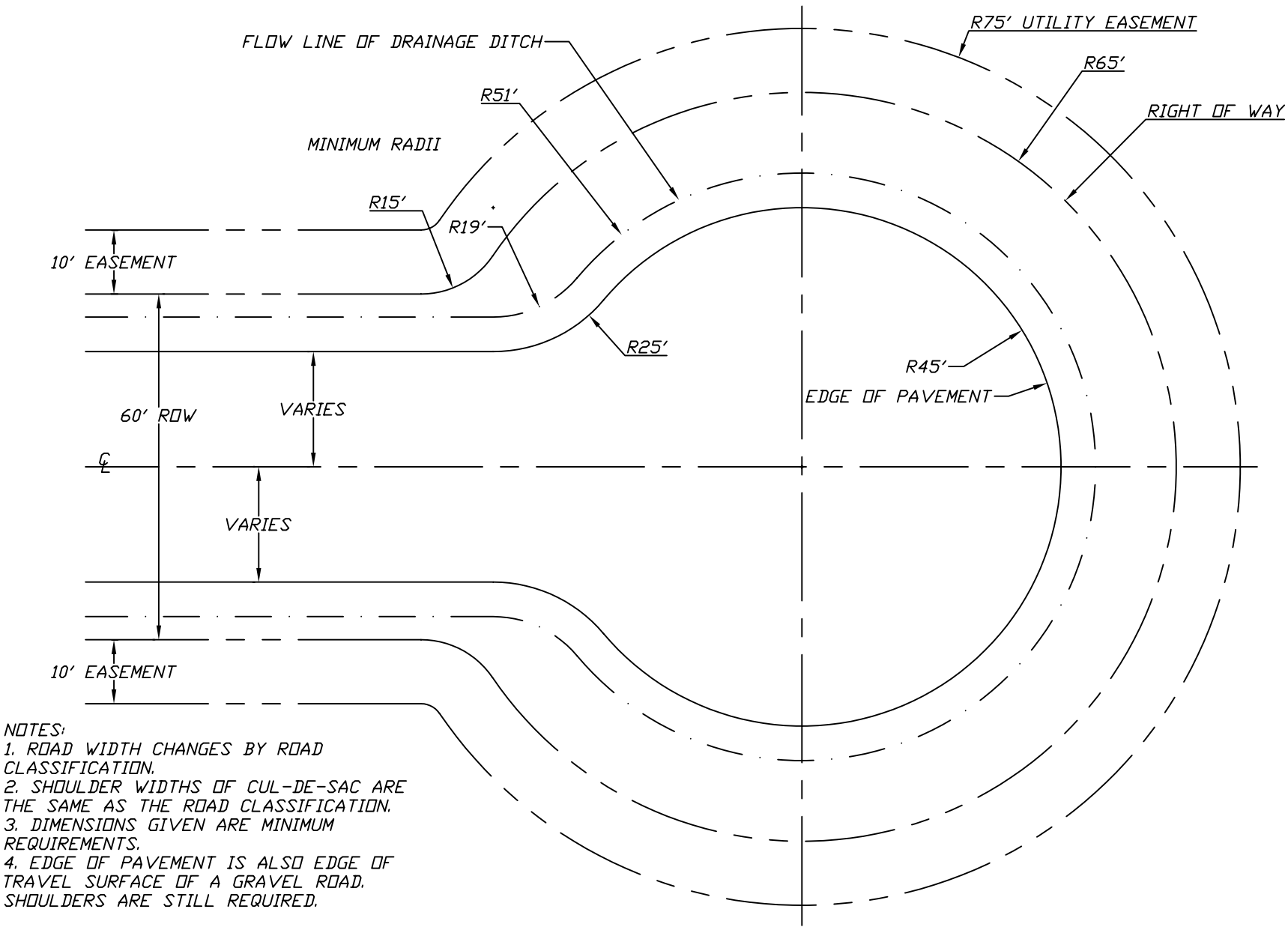

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416


TITLE
RURAL DRIVEWAYS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/17/08 |

SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 11/17/08 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 16




NOTES:
1. ROAD WIDTH CHANGES BY ROAD CLASSIFICATION.
2. SHOULDER WIDTHS OF CUL-DE-SAC ARE THE SAME AS THE ROAD CLASSIFICATION.
3. DIMENSIONS GIVEN ARE MINIMUM REQUIREMENTS.
4. EDGE OF PAVEMENT IS ALSO EDGE OF TRAVEL SURFACE OF A GRAVEL ROAD. SHOULDERS ARE STILL REQUIRED.

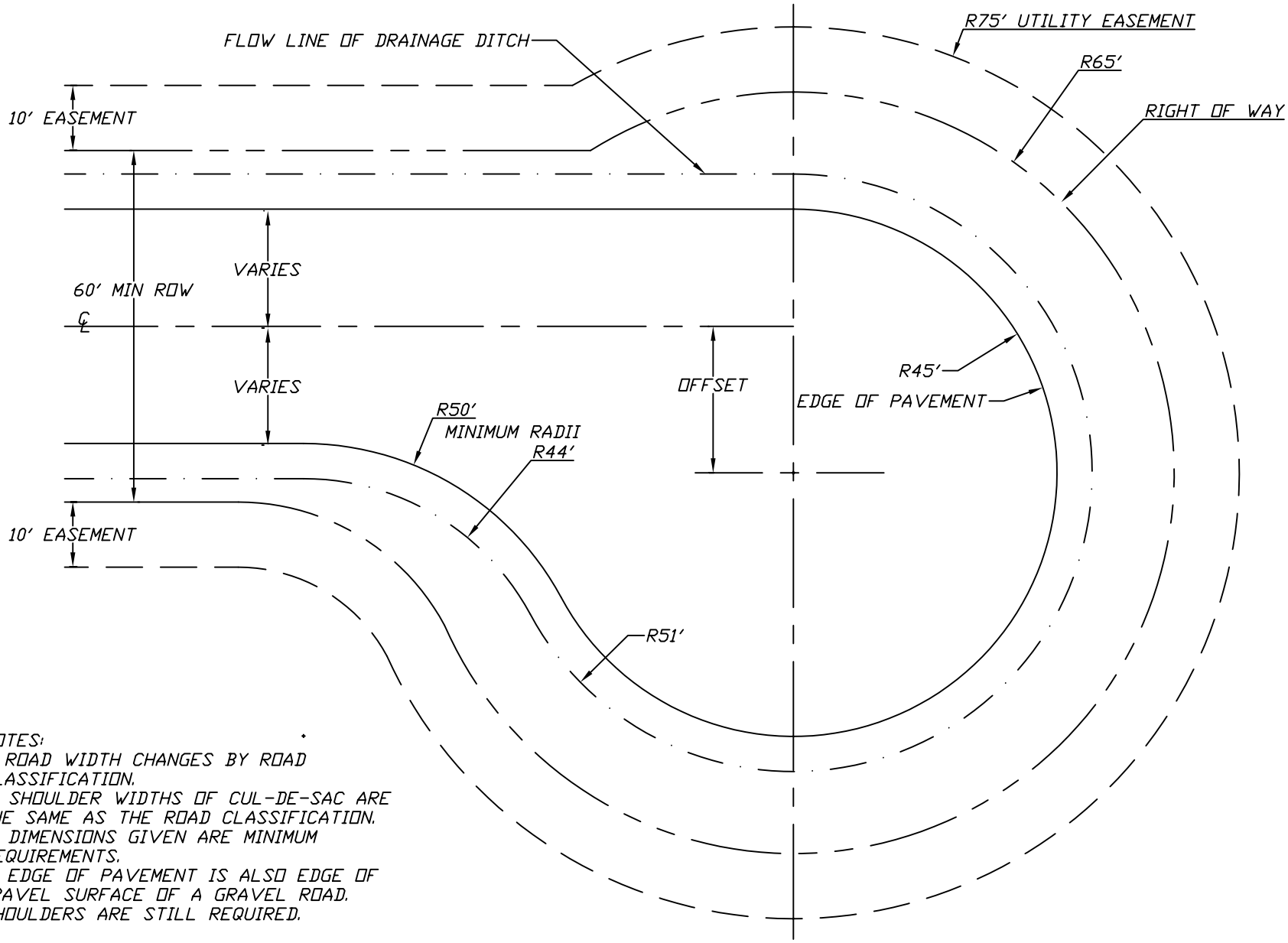
DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
# CUL-DE-SAC DETAIL
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/19/08 |

SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 11/19/08
DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 17




NOTES:
1. ROAD WIDTH CHANGES BY ROAD CLASSIFICATION.
2. SHOULDER WIDTHS OF CUL-DE-SAC ARE THE SAME AS THE ROAD CLASSIFICATION.
3. DIMENSIONS GIVEN ARE MINIMUM REQUIREMENTS.
4. EDGE OF PAVEMENT IS ALSO EDGE OF TRAVEL SURFACE OF A GRAVEL ROAD. SHOULDERS ARE STILL REQUIRED.

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

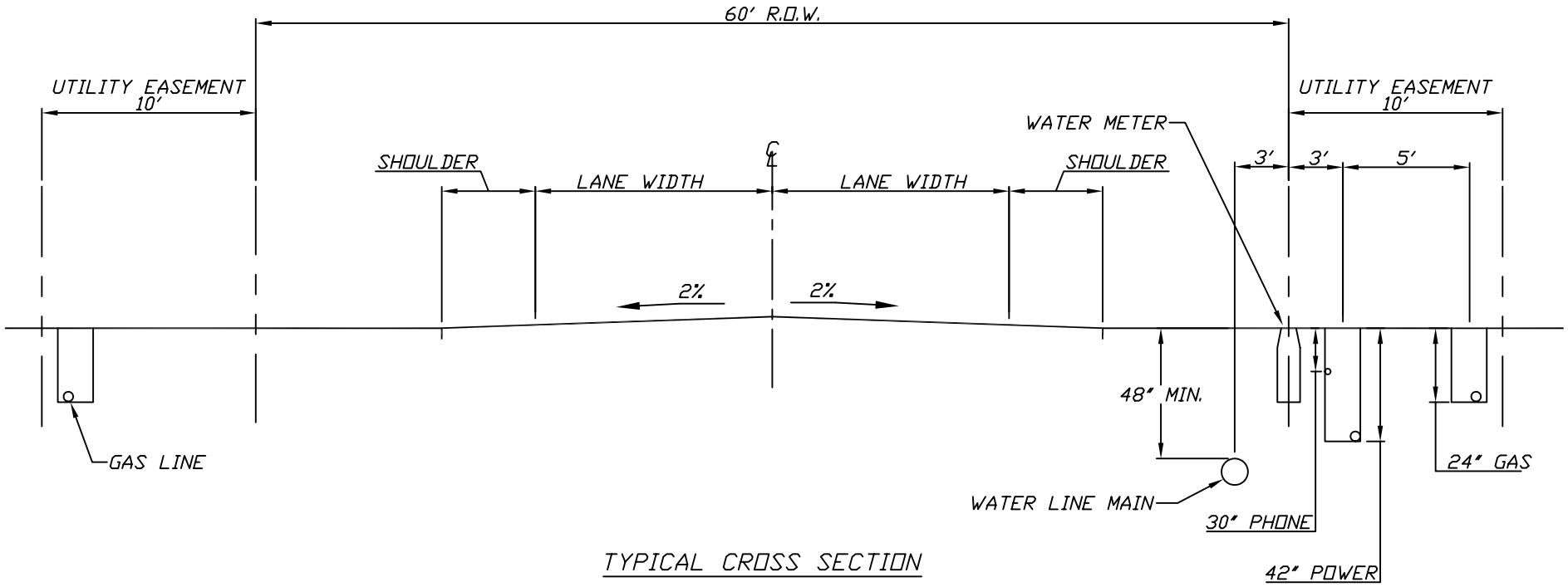
TITLE
OFFSET CUL-DE-SAC

DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/19/08 |

SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 11/19/08
DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 18




## TYPICAL CROSS SECTION
## UTILITY LOCATION AND EASEMENTS
## FOR A 60 FOOT RIGHT OF WAY

NOTE:
1. MINIMUM COVER OVER WATER LINE FOR TRI COUNTY IS 34".
2. MINIMUM COVER OVER WATER LINE ALL OTHERS BELOW 6500 FOOT ELEVATION IS 48".
3. MINIMUM COVER OVER WATER LINE 6500 TO 9000 FEET IN ELEVATION IS 54".
4. MINIMUM COVER OVER WATER LINE 9000 FEET AND UP IN ELEVATION IS 60".

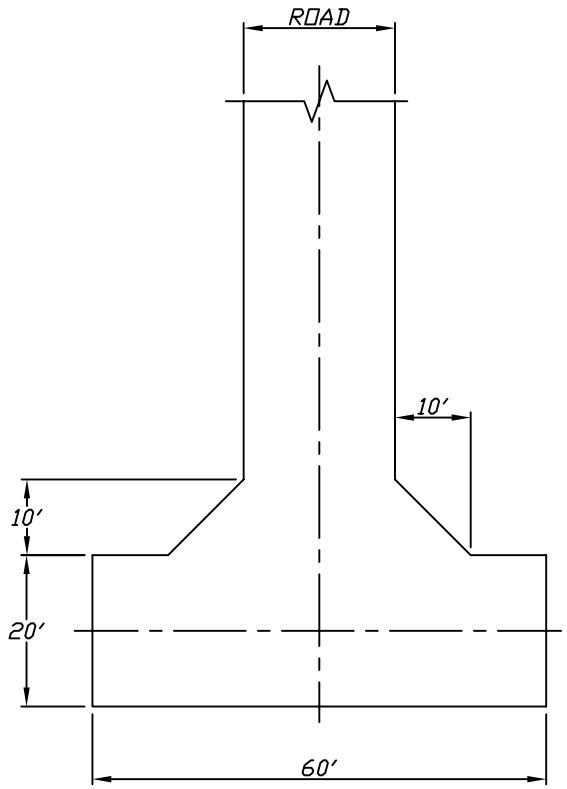
DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
UTILITY LOCATIONS AND EASEMENTS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

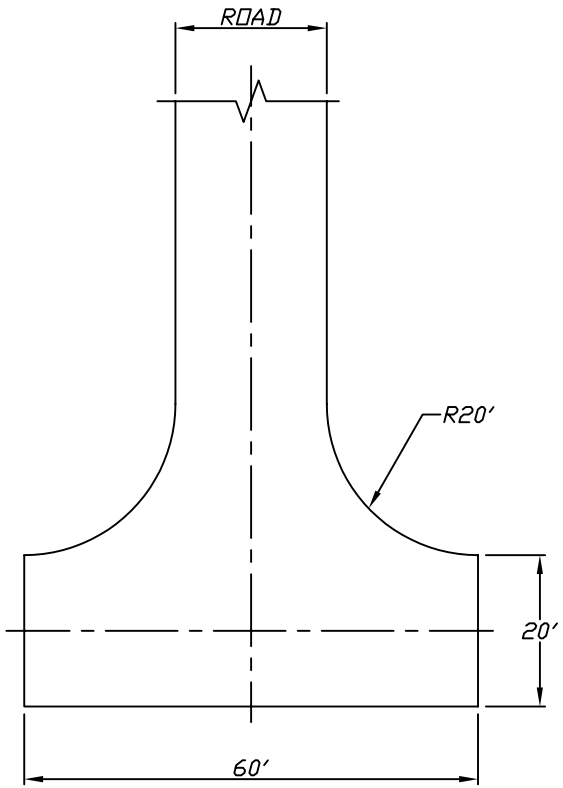
| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/19/08 |

SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 11/19/08 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

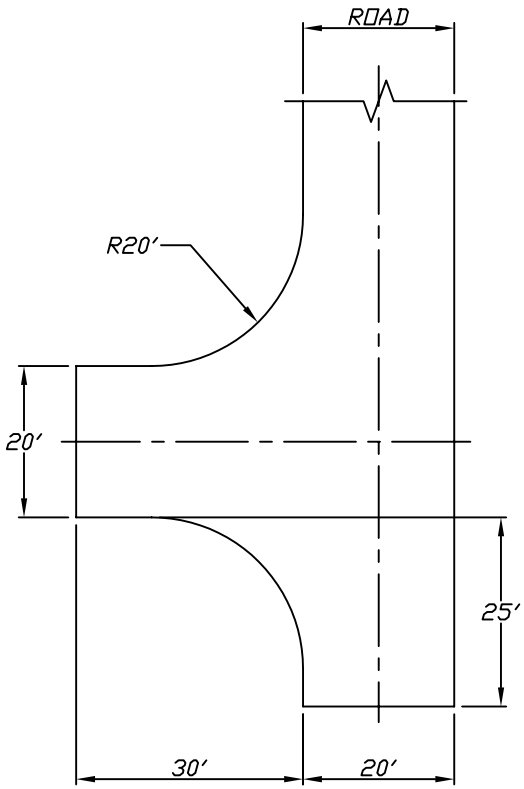
ITEM 19




OPTION A




OPTION B




OPTION C

NOTE: DIMENSIONS SHOWN ARE TYPICAL AS SHOWN.

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
TURNABOUT DESIGNS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 11/20/08 |

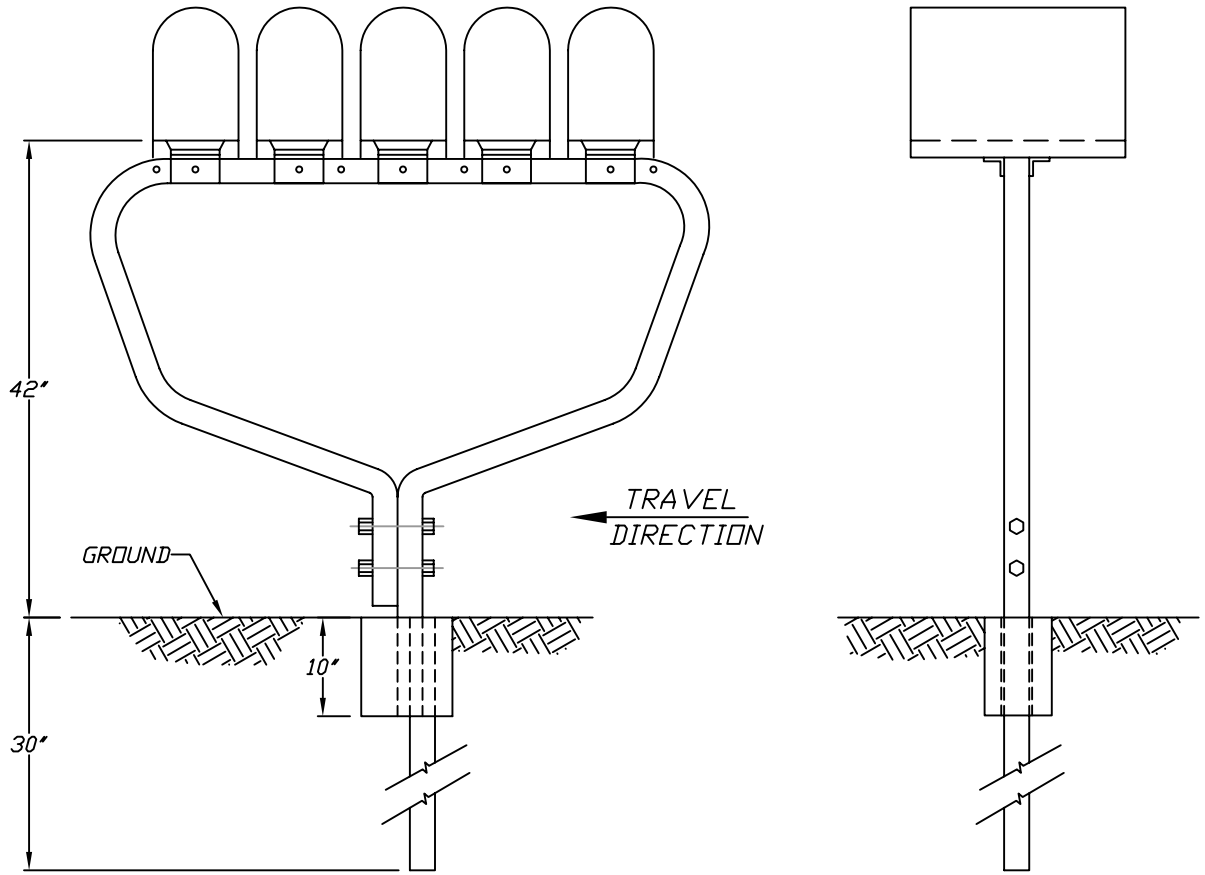
SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 11/20/08
DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP5

ITEM 20

# Appendix 6

# Roadway

# Appurtenances




GENERAL NOTES:

POSTS, BRACKETS AND ALL MOUNTING HARDWARE MUST BE GALVANIZED.

PLASTIC NEWSPAPER RECEPTACLES MAY BE MOUNTED BELOW THE MAILBOX ON THE SUPPORT BAR.

ON ROADS WITH CURB AND GUTTER THE MAILBOX SUPPORT SHALL BE MOUNTED 8" TO 12" BEHIND THE FACE OF THE CURB. THE HEIGHT SHALL BE 42" TO 48" MEASURED FROM THE GUTTER FLOWLINE TO THE BOTTOM OF THE MAILBOX.
REFER TO THE COLORADO DEPARTMENT OF TRANSPORTATION STANDARD PLANS M-210-1 & 2 FOR ADDITIONAL INFORMATION.

PARTIAL LIST OF MANUFACTURERS:
FORESIGHT PRODUCTS INC.
TRAFFIC & PARKING CONTROL CO.

MULTIPLE (TYPE 3) MAILBOX SUPPORT
FOR 3, 4, OR 5 MAILBOXES OR APPROVED EQUAL

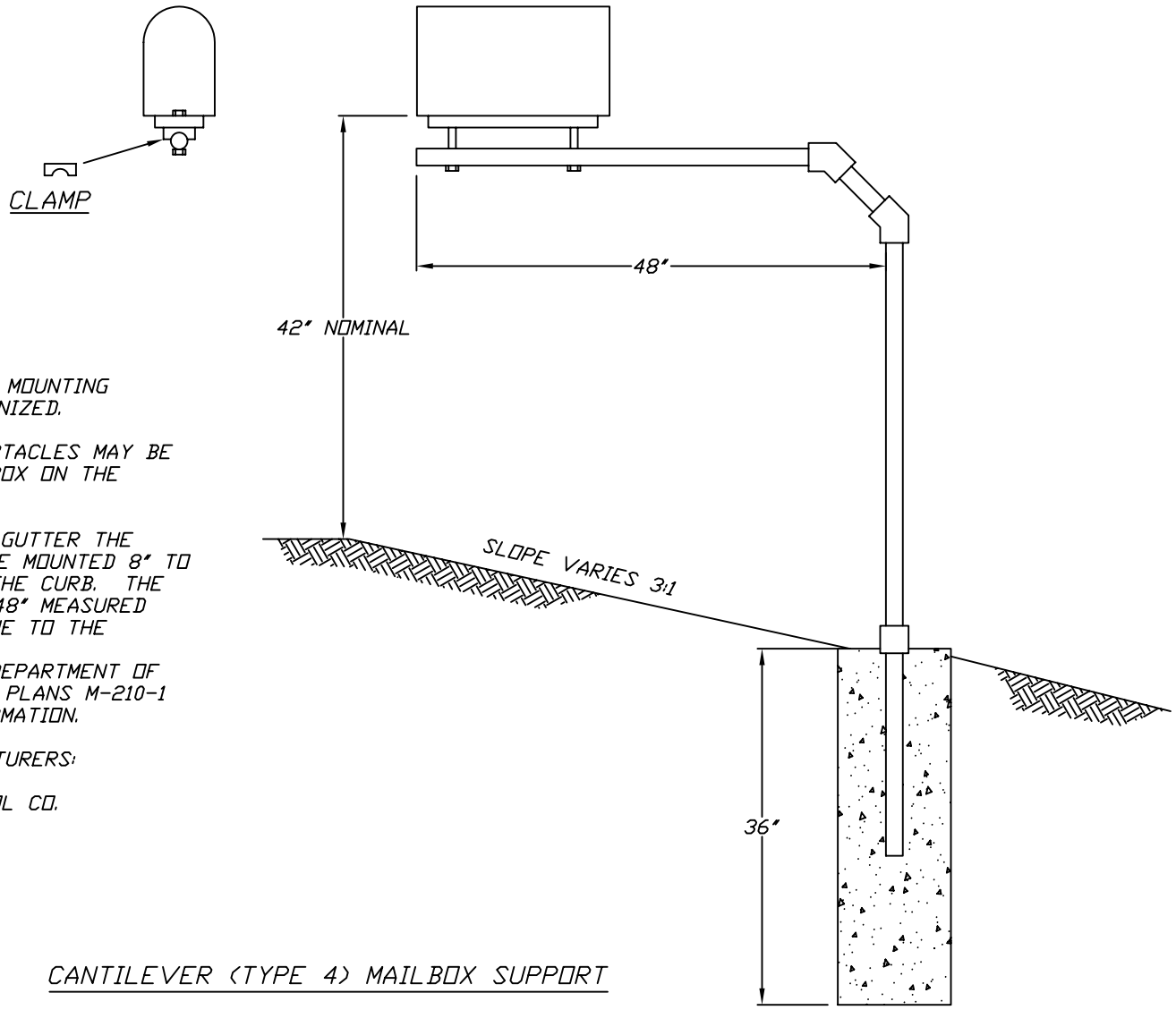
DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
MAILBOX SUPPORTS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 2/9/09 |

SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 2/9/09 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6

ITEM 1




GENERAL NOTES:

POSTS, BRACKETS AND ALL MOUNTING HARDWARE MUST BE GALVANIZED.

PLASTIC NEWSPAPER RECEPTACLES MAY BE MOUNTED BELOW THE MAILBOX ON THE SUPPORT BAR.

ON ROADS WITH CURB AND GUTTER THE MAILBOX SUPPORT SHALL BE MOUNTED 8" TO 12" BEHIND THE FACE OF THE CURB. THE HEIGHT SHALL BE 42" TO 48" MEASURED FROM THE GUTTER FLOWLINE TO THE BOTTOM OF THE MAILBOX.
REFER TO THE COLORADO DEPARTMENT OF TRANSPORTATION STANDARD PLANS M-210-1 & 2 FOR ADDITIONAL INFORMATION.

PARTIAL LIST OF MANUFACTURERS:
FORESIGHT PRODUCTS INC.
TRAFFIC & PARKING CONTROL CO.

CANTILEVER (TYPE 4) MAILBOX SUPPORT

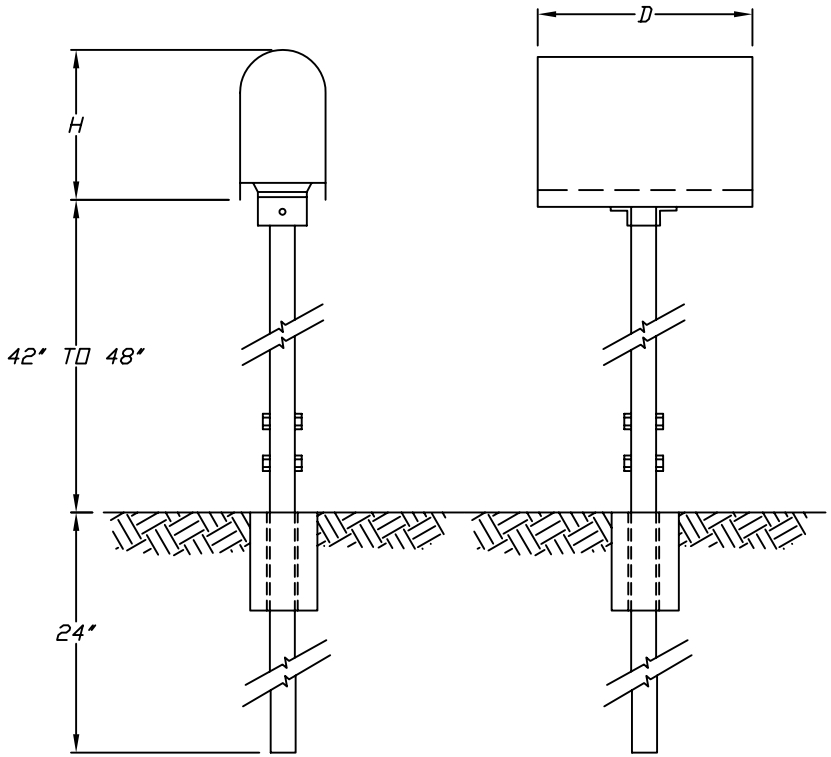
DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
MAILBOX SUPPORTS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

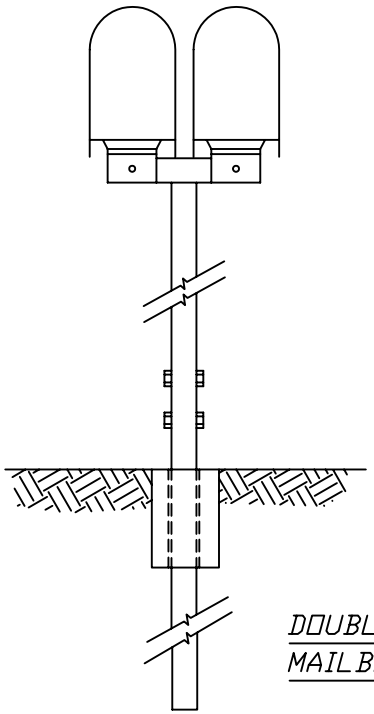
| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 2/10/09 |

SCALE: NOT TO SCALE | DESIGNED: DELTA COUNTY
DATE: 2/10/09 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6

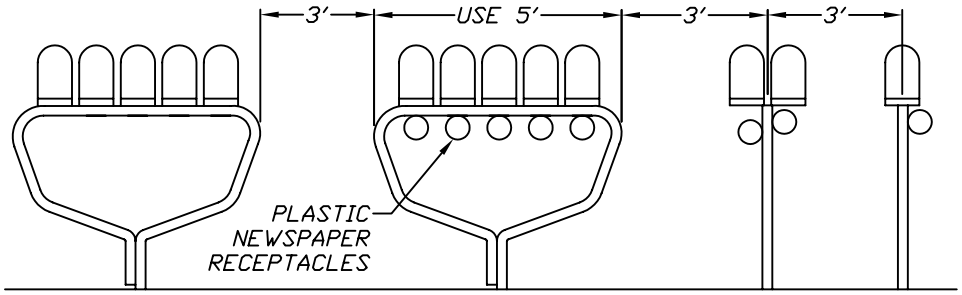
ITEM 2




SINGLE (TYPE 1) MAILBOX SUPPORT



DOUBLE (TYPE 2)
MAILBOX SUPPORT




SUPPORT SPACING

GENERAL NOTES:

POSTS, BRACKETS AND ALL MOUNTING HARDWARE MUST BE GALVANIZED.

PLASTIC NEWSPAPER RECEPTACLES MAY BE MOUNTED BELOW THE MAILBOX ON THE SUPPORT BAR.

ON ROADS WITH CURB AND GUTTER THE MAILBOX SUPPORT SHALL BE MOUNTED 8" TO 12" BEHIND THE FACE OF THE CURB. THE HEIGHT SHALL BE 42" TO 48" MEASURED FROM THE GUTTER FLOWLINE TO THE BOTTOM OF THE MAILBOX. REFER TO THE COLORADO DEPARTMENT OF TRANSPORTATION STANDARD PLANS M-210-1 & 2 FOR ADDITIONAL INFORMATION.

PARTIAL LIST OF MANUFACTURERS:
FORESIGHT PRODUCTS INC.
TRAFFIC & PARKING CONTROL CO.

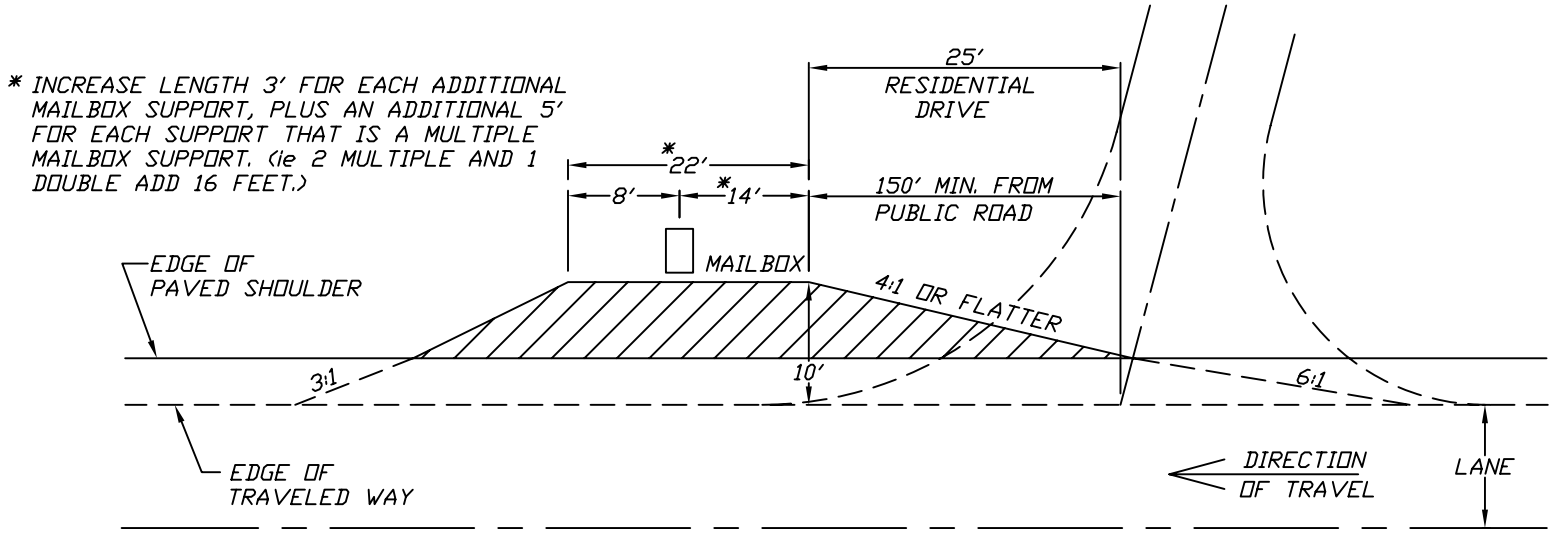
DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
MAILBOX SUPPORTS
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

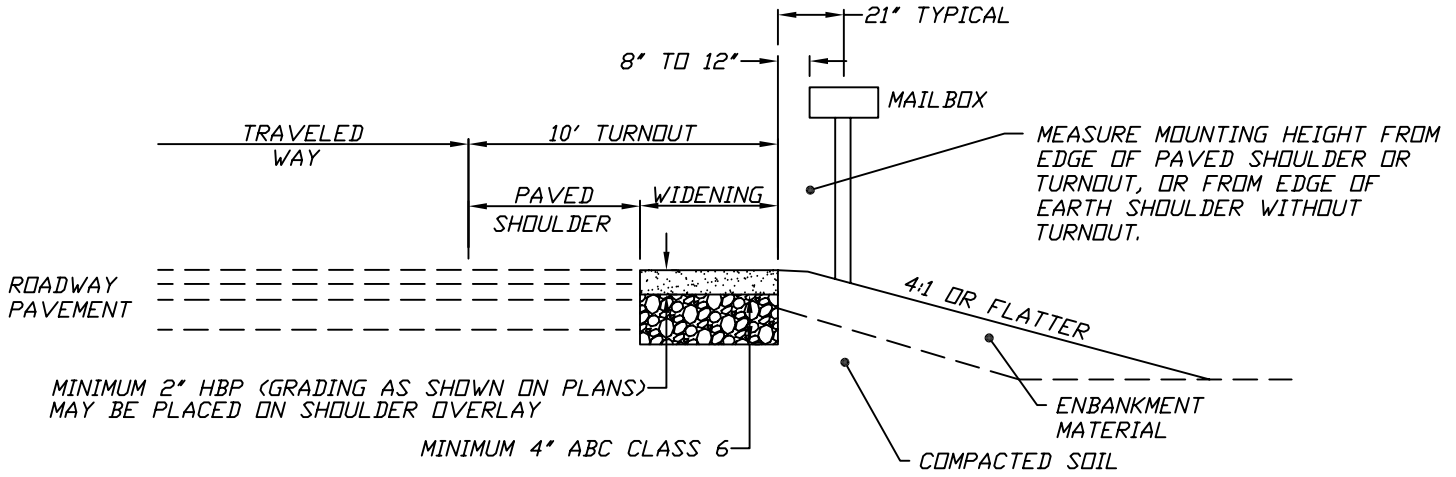
| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 2/10/09 |

SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 2/10/09
DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6

ITEM 3

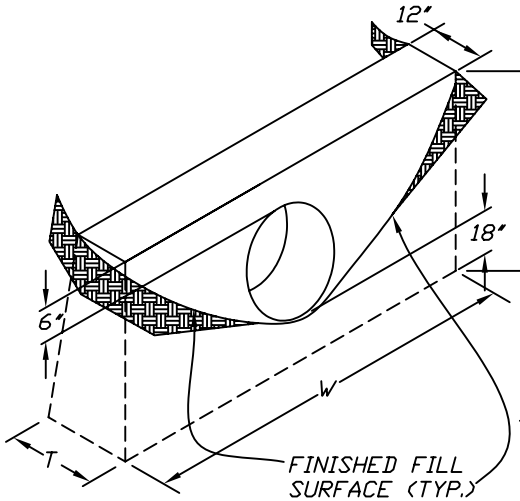



MAILBOX TURNOUT

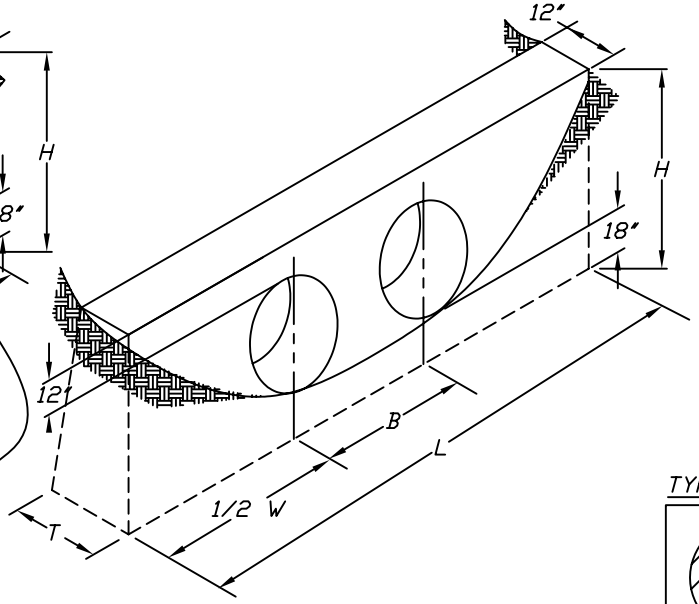



TURNOUT TYPICAL SECTION

| | | | | | |
|---|---|---|---|---|---|
| DELTA COUNTY<br>OFFICE OF THE COUNTY ENGINEER<br>501 PALMER STREET DELTA, CO 81416 | TITLE<br>MAILBOX TURNOUT<br>DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS | RJB BY | REDRAWN<br>REVISION DESCRIPTION | 2/4/09<br>DATE | SCALE: NOT TO SCALE<br>DESIGNED: DELTA COUNTY<br>DATE: 2/4/09<br>DRAWN: RJB<br>ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6 | ITEM 4 |



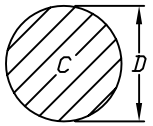

SINGLE PIPE




DOUBLE PIPE

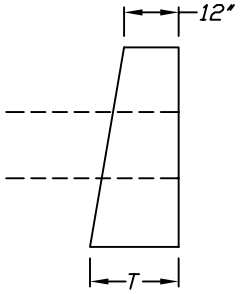
GENERAL NOTES:

FOR SIZE AND LOCATION OF CULVERTS, SEE PLANS.
ALL CONCRETE SHALL BE CLASS B.
FOOTINGS IN ROCK SHALL BE POURED OUT TO ROCK AND NOT FORMED.
EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED 3/4 IN.

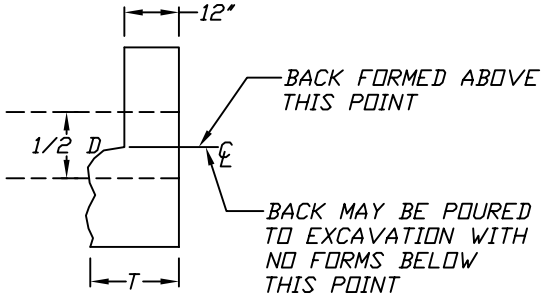
| TYPE OF PIPE | HEADWALL DIMENSIONS |
|---|---|
|  CIRCULAR | D = PIPE DIAMETER<br>H = D + 30"<br>W = 3D + 18"<br>T = 0.4H (NEAREST INCH)<br>2 = 1.5D (1 FOOT MIN. 4 FEET MAX.)<br>L = W + H |



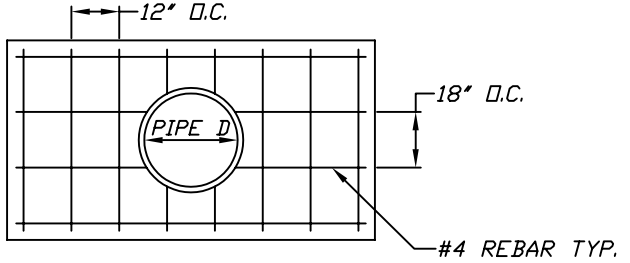
NOTE: HEADWALLS FOR PIPE 48 INCHES OR LARGER IN DIAMETER MUST BE DESIGNED BY LICENCED ENGINEER.




SIDE VIEW




ALTERNATE CONSTRUCTION
SIDE VIEW




REBAR DETAIL

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
CULVER HEADWALLS
PIPES SMALLER THAN 48 INCH DIAMETER
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 2/4/09 |

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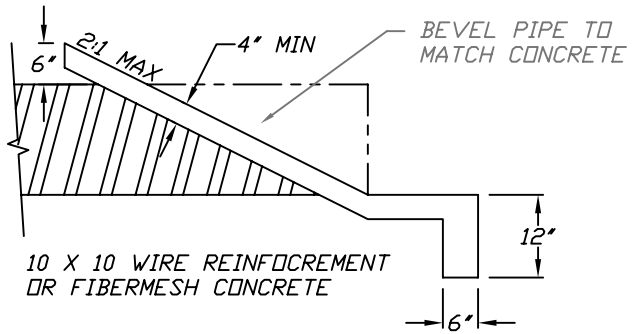
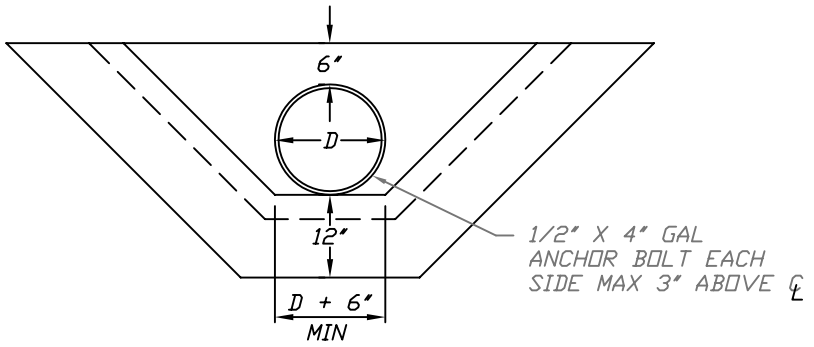
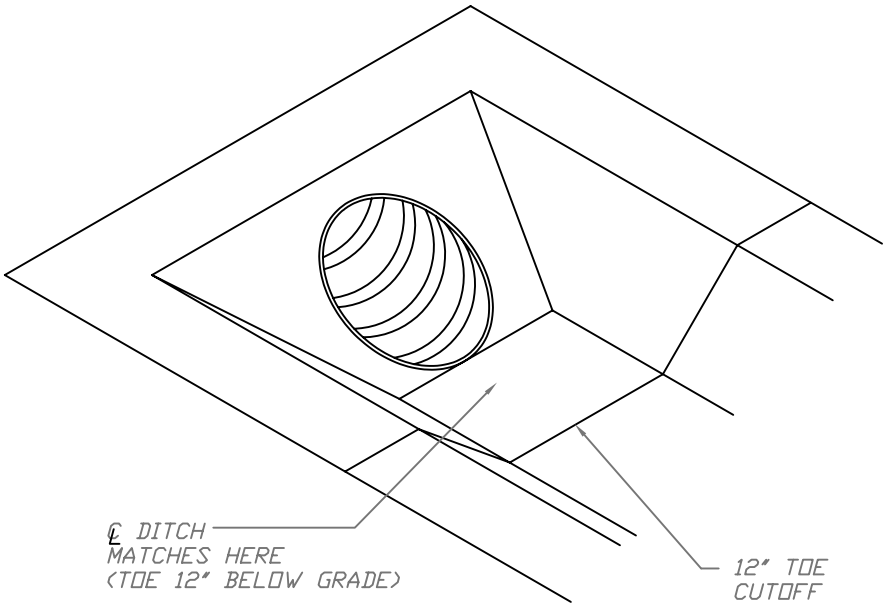
ITEM 5

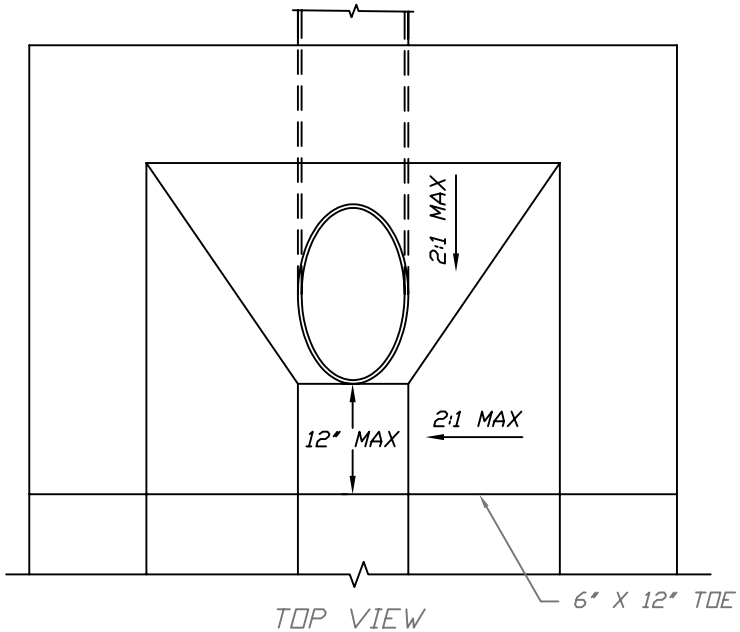



FRONT VIEW

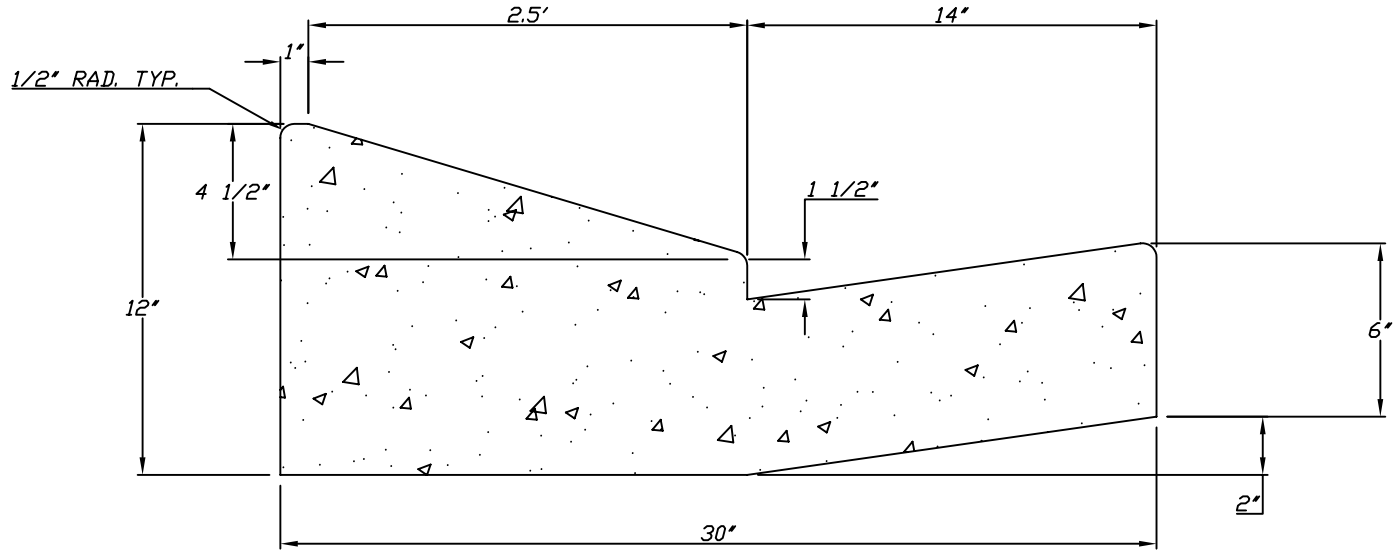



ISOMETRIC VIEW



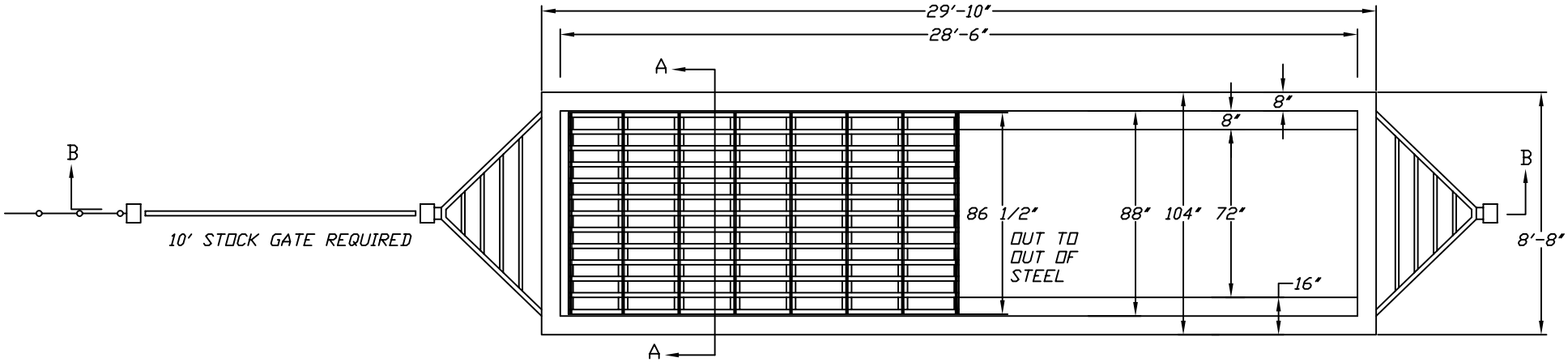

TOP VIEW

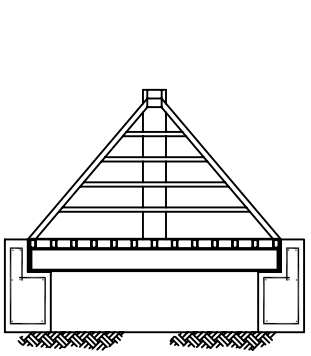
| | | | | | |
|---|---|---|---|---|---|
| DELTA COUNTY<br>OFFICE OF THE COUNTY ENGINEER<br>501 PALMER STREET DELTA, CO 81416 | TITLE<br>CULVERT INLET/OUTLET DESIGN<br>DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS | RJB BY | REDRAWN<br>REVISION DESCRIPTION | 2/4/09<br>DATE | SCALE: NOT TO SCALE<br>DATE: 2/4/09<br>ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6 | DESIGNED: DELTA COUNTY<br>DRAWN: RJB | ITEM 6 |



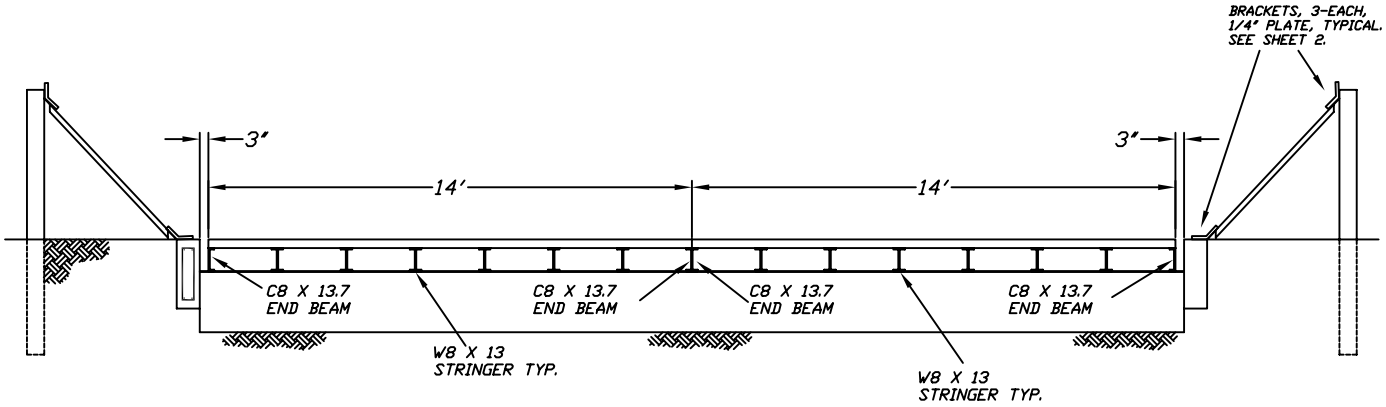

TYPICAL SECTION

| | | | | | |
|---|---|---|---|---|---|
| DELTA COUNTY<br>OFFICE OF THE COUNTY ENGINEER<br>501 PALMER STREET DELTA, CO 81416 | TITLE<br>RAMP CURB<br>DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS | RJB BY | REDRAWN<br>REVISION DESCRIPTION | 2/3/09<br>DATE | SCALE: NOT TO SCALE<br>DESIGNED: DELTA COUNTY<br>DATE: 2/3/09<br>DRAWN: RJB<br>ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6 | ITEM 7 |



SECTION AA
SEE DETAILS SHEET 2




SECTION BB
SEE DETAILS SHEET 2



DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
CATTLE GUARD

DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 1/5/09 |

SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 1/5/09
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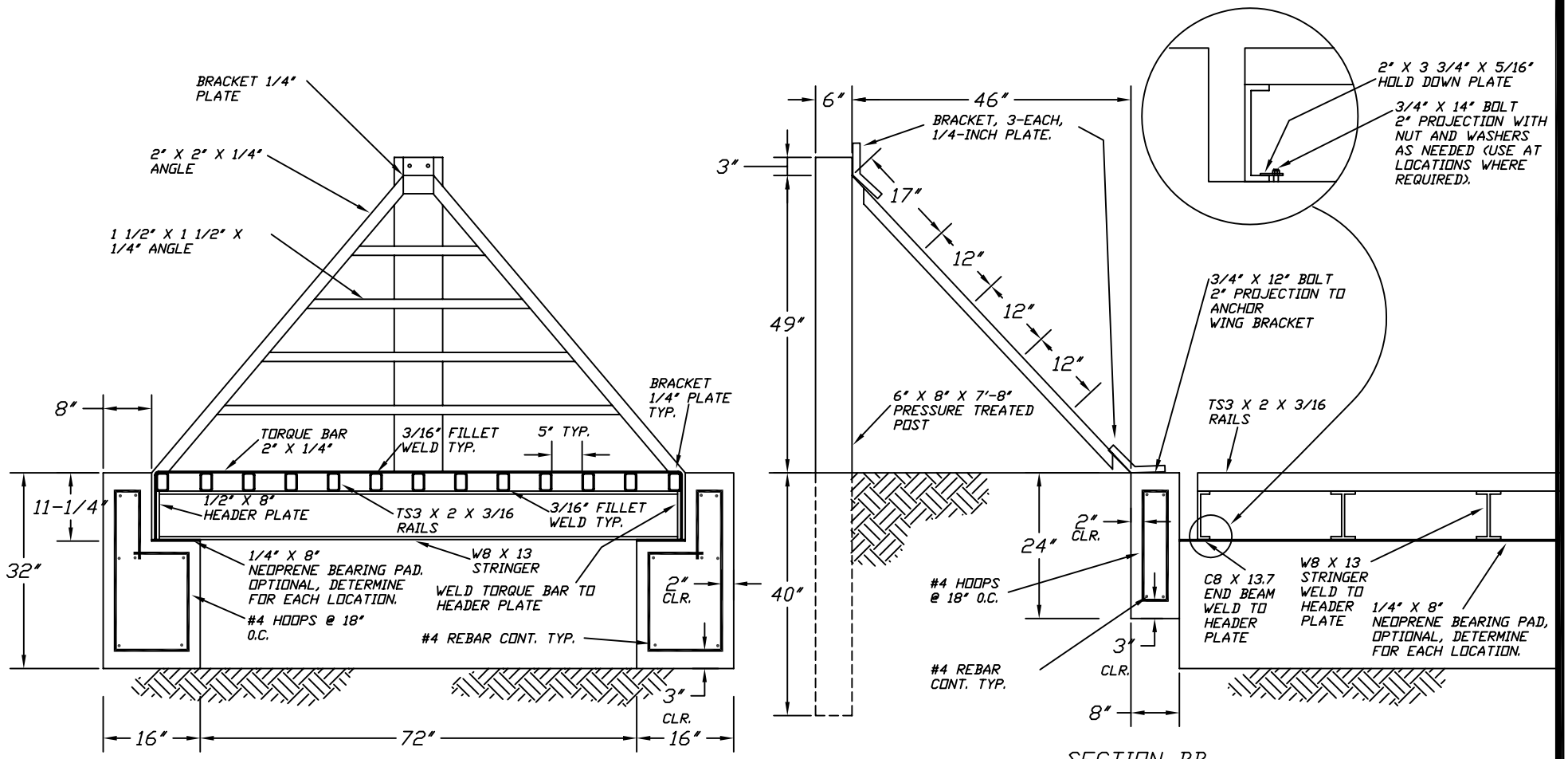
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6

ITEM 8





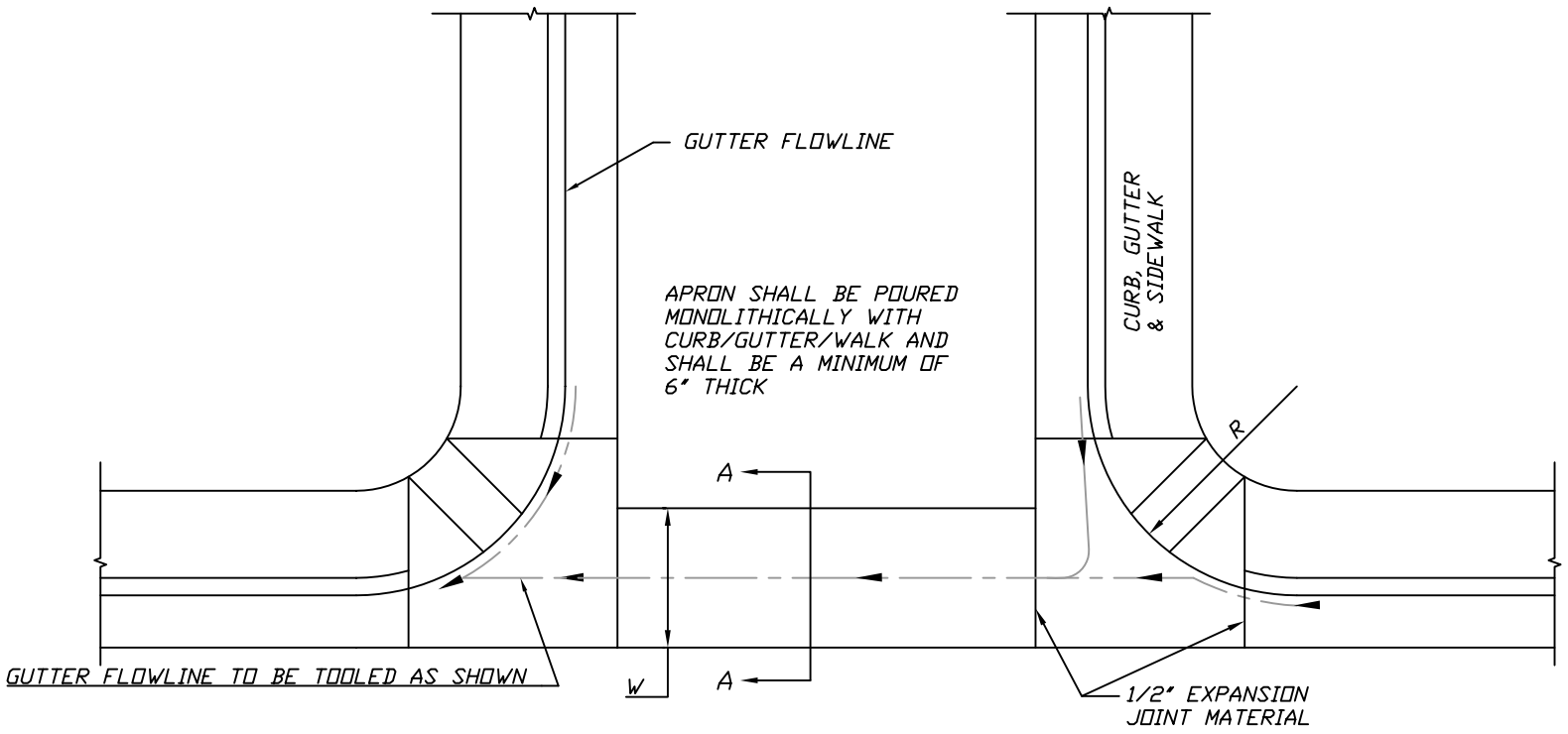

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

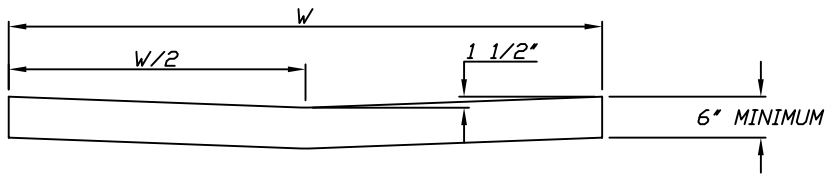
TITLE
# CATTLE GUARD
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 1/5/09 |

SCALE: NOT TO SCALE
DESIGNED: DELTA COUNTY
DATE: 1/5/09
DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6

ITEM 9




SECTION A-A

| |
|---|
| W = CROSS PAN WIDTH |
| W = 8' MINIMUM AT INTERSECTIONS WITH A CONTROLLED STOP. |
| W = 12' MINIMUM FOR ALL OTHER INTERSECTIONS. |
| W = 6' MINIMUM FOR RESIDENTIAL DRIVEWAYS. |

DELTA COUNTY
OFFICE OF THE COUNTY ENGINEER
501 PALMER STREET DELTA, CO 81416

TITLE
CROSS PAN DETAIL
DELTA COUNTY ROADWAY DESIGN AND CONSTRUCTION STANDARDS

| BY | REVISION DESCRIPTION | DATE |
|---|---|---|
| RJB | REDRAWN | 1/5/09 |

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DATE: 1/5/09 | DRAWN: RJB
ABBREVIATED FILE LOCATION: M:\ENG\LIB\ROAD\DEL\IMA\AAP6

ITEM 10

# Appendix 7

# Asphalt Pavement and Gravel Road Design Examples

# Item 1
# Asphalt Pavement

As an example to illustrate the procedure and requirements of Appendix, assume the following:

- Collector functional classification
- HVEEM test R value of 20
- Projected traffic volume equivalent to the minimum 18K EDLA value of 30 for a minor collector

From the equations in Appendix 4:

$S_1 = [(20 – 5)/11.29] + 3 = 4.33$

$M_R = 10^{(S_1 = 18.72)/ 6.24} = 4898$ (use 5000)

Convert EDLA to ESAL (20 year design period)

30 x 20 x 365 = 219,000

From Appendix 4, the reliability factor for a collector is 80.

From Item 11 in Appendix 4:

Modulus for base course with structural coefficient of 0.12 is approximately 26,000

Modulus for sub base course with structural coefficient of 0.10 is approximately 21,000

From the nomograph in Item 4 of Appendix 1 ) read the following structural numbers for layered design per Item 3, Appendix 4:

$SN_1 = 1.45$

$SN_2 = 1.65$

$SN_3 = 2.7$

Per the procedure described in Appendix 4 and illustrated in Item 3, Appendix 4:

$D^*_1 \geq SN_1 / a_1 = 1.45/0.44 = 3.3$ use 3.5

$SN^*_1 = a_1 D^*_1 \geq SN_1 = (3.5)(0.44) = 1.54$

$D^*_2 \geq SN_2 - SN^*1/a_2 m_2 = (1.65 - 1.54)/0.12 = 1$ use 6 inch min.

$SN^*_1 + SN^*_2 \geq SN_2 = (0.12)(6) + (3.5)(0.44) = 2.26$; >1.65 ok

$D^*_3 \geq SN_3 - (SN^*_1 + SN^*_2)/ a_3 m_3 = (2.7 - 2.26)/0.10 = 4.4$ use 5.0

Total = $SN^*_1 + SN^*_2 + SN^*3 = 1.54 = 0.72 = 0.50 = 2.76 > 2.7$ ok

Therefore use the following thickness:

Depth of HBP ($D^*_1$) – 3.5 inches

Depth of Class 6 base course ($D^*_2$) – 6 inches

Depth of Class 2 sub-base-course ($D^*_3$) – 5 inches

The above would be the minimum allowed values.

If a full depth asphalt design were proposed for this example, the required depth would be:

$D_{fda} = SN_3/a_1 = 2.7/0.44 = 6.14$; use 6.5 inches

# Item 2
# GRAVEL ROAD DESIGN

The primary design requirements for aggregate surfaced roads include:

- Predicted future traffic for the design period
- The lengths of the seasons
- Seasonal resilient moduli of the roadbed soil
- Elastic modulus, $E_{BS}$ (psi), of the aggregate base layer (from HVEEM or other testing. $M_R$ value)
- Elastic modulus, $E_{BS}$ (psi), of the aggregate sub base later (from HVEEM or other testing $M_R$ value)
- Design serviceability loss, $\Delta PSI$
- Allowable rutting, RD (inches), in surface layer , and
- Aggregate loss, GL (inches), of surface layer

Reference Appendix 4 for further details on these requirements.

These design requirements are used in conjunction with the computational chart Item12 in Appendix 4 and the design nomographs for serviceability (Item 6, Appendix 4) and rutting (Item 8, Appendix 4). The following steps outline the procedure:

Step 1: Select four levels of aggregate base thickness, $D_{BS}$ , which should bound the probable solution. Prepare four separate tables, one for each trial thickness utilizing the Road Design Worksheet (Item12, Appendix 4). On each of the four tables enter the trial base thickness, $D_{BS}$; design serviceability loss, $\Delta PSI$; and the allowable rutting, RD, in the appropriate boxes.

Step 2: Enter the appropriate seasonal resilient (elastic) moduli of the roadbed ($M_R$) and the aggregate base material, $E_{BS}$, in columns 2 and 3, respectively, of the worksheet. The base modulus values may be proportional to the resilient modulus of the roadbed soil during a given season. However, a constant value of 30,000 psi was used in the example, which follows, since a portion of the aggregate base material will be converted into an equivalent thickness of sub base material (which will provide some shield against the environmental moisture effects).

Step 3: Enter the seasonal 18-kip ESAL traffic in column 4 of the worksheet. Assuming that truck traffic is distributed evenly throughout the year, the lengths of the seasons should be used to proportion the total projected 18-kip ESAL traffic to each season. If the road is load zoned (restricted) during certain critical periods, the total traffic may be distributed only among those seasons when truck traffic is allowed. Total traffic of 36,500 18-kip ESAL applications (the minimum 5 EDLA and a 20 year design period) and a seasonal pattern corresponding to U. S. Climatic Region VI was used in the example.

Step 4: Within each of the four tables, estimate the allowable 18-kip ESAL traffic for each of the four seasons using the serviceability-based nomograph (Item 6) and enter the result in column 5. If the resilient modulus of the roadbed soil (during the frozen season) is such that the allowable traffic exceeds the upper limit of the nomograph, assume a practical value of 500,000 18-kip ESAL.

Step 5: Within each of the four tables estimate the allowable 18-kip ESAL traffic for the four seasons, using the rutting –based nomograph (Item 9) and enter the result in column 7. Again, if the resilient modulus of the roadbed soil is such that the allowable traffic exceeds the upper limit of the nomograph, assume a practical value of 500,000 18-kip ESAL.

Step 6: Compute the seasonal damage values in each of the four tables for the serviceability criteria by dividing the projected seasonal traffic (column 4) by the allowable traffic in that season (column 5). Enter these seasonal damage values in column 6 of the worksheet corresponding to serviceability criteria. Next, follow these same instructions for rutting criteria, i.e., divide column 4 by column 7 and enter in column 8.

Step 7: Compute the total damage for both the serviceability and rutting criteria by adding the seasonal damages. When this is accomplished for all four tables, a graph of total damage versus base layer thickness should be prepared. The average base layer thickness, $\underline{D}_{BS}$, required is determined by interpolating in this graph for a total damage equal to 1.0. The chart which follows provides an example in which the design is controlled by the serviceability criteria.

Step 8: The base layer thickness determined in the last step should be used for design if the effects of aggregate loss are negligible. If, however, aggregate loss is significant, the design thickness is determined by using the following equation:

$$D_{BS} = \underline{D}_{BS} + (0.5 \times GL)$$

where GL = total estimated aggregate (gravel) loss (in inches) over the performance period.

Step 9: The final step of the design chart procedure for aggregate surfaced roads is to convert a portion of the aggregate base layer thickness to an equivalent thickness of sub base material. This is accomplished with the aid of Item 9, Appendix 4. Select the final base thickness desired, $D_{BS}$ (6inches is used in this example). Draw a line to the estimated modulus of the sub base material, $E_{BS}$. Go across and through the scale corresponding to the reduction of in base thickness, $D_{BSi} - D_{BSi}$. Then for the known modulus of the base material, $E_{BS}$, determine the required sub base thickness, $D_{SB}$.

As an example to illustrate the described procedure and the requirements of Appendix 4, assume the following:

- HVEEM R value of 20 for the roadbed soil.
- The minimum required EDLA of 5, over a 20 year design period for a total traffic of 365,000 18-kip ESAL.

Assume 6, 8, 10, and 12 inches of base thickness for preparation of the four tables. Per Appendix 4, Gravel Road Design, the design serviceability loss is 3, and the allowable rutting is 2.

Proportion the total projected 18-kip ESAL traffic into seasonal traffic values for column 4 according to the lengths of season specified in 6.6.1e.

The results of the proceeding, according to steps 4, 5, and 6 above, are shown in the example tables which follow.

The graph which follows is of total damage versus base layer thickness for this example. The serviceability criteria require a larger thickness of base than the rutting criteria. Use the higher value (11.6 inches) for design.

Gravel loss is specified for design purposes in 6.6.1b as 2 inches, therefore the required thickness, $D_{BS}$, is:

DBS = DBS + (0.5x GL) = 11.6 + (0.5 + 2) = 12.6 inches.

Use the chart for equivalent thickness – sub-base vs. base which follows to determine the amount of sub base material required to reduce the base thickness by 6 inches.

## EXAMPLE ASSUMING 6 INCHES BASE COURSE

| TRIAL BASE THICKNESS, DBS, (INCHES) _____6_____ | | | | SERVICEABILITY CRITERIA PSI =_____3_____ | | RUTTING CRITREIA RD (INCHES_____2____ | |
|---|---|---|---|---|---|---|---|
| (1) SEASON (ROADBED MOISTURE CONDITION) | (2) ROADBED RESILIENT MODULUS $M_R$ (psi) | (3) BASE ELASTIC MODULUS $E_{BS}$ (psi) | (4) PROJECTED 18-KIP ESAL TRAFFIC $W_{18}$ | (5) ALLOWABLE 18-KIP ESAL TRAFFIC $W_{18}$(psi) | (6) SEASONAL DAMAGE $W_{18}/W_{18}$(psi) | (7) ALLOWABLE 18-KIP ESAL TRAFFIC $(W_{18})_{RUT}$ | (8) SEASONAL DAMAGE $W_{18}/W_{18})_{RUT}$ |
| WINTER (FROZEN | 20,000 | 30,000 | 9,125 | 32,000 | 0.29 | 350,000 | 0.03 |
| SPRING/THAW (SATURATED) | 1,500 | 30,000 | 4,563 | 2,200 | 2.07 | 3,500 | 1.30 |
| SPRING/FALL (WET) | 3,300 | 30,000 | 9,125 | 5,000 | 1.83 | 4,500 | 2.03 |
| SUMMER (DRY) | 4,900 | 30,000 | 13,687 | 7,000 | 1.96 | 7,500 | 1.82 |
| | | TOTAL TRAFFIC = | 36,500 | TOTAL DAMAGE = | 6.15 | TOTAL DAMAGE = | 5.18 |

## EXAMPLE ASSUMING 8 INCHES BASE COURSE

| TRIAL BASE THICKNESS, DBS, (INCHES) _____8_____ | | | | SERVICEABILITY CRITERIA PSI =_____3_____ | | RUTTING CRITREIA RD (INCHES_____2____ | |
|---|---|---|---|---|---|---|---|
| (1) SEASON (ROADBED MOISTURE CONDITION) | (2) ROADBED RESILIENT MODULUS $M_R$ (psi) | (3) BASE ELASTIC MODULUS $E_{BS}$ (psi) | (4) PROJECTED 18-KIP ESAL TRAFFIC $W_{18}$ | (5) ALLOWABLE 18-KIP ESAL TRAFFIC $W_{18}$(psi) | (6) SEASONAL DAMAGE $W_{18}/W_{18}$(psi) | (7) ALLOWABLE 18-KIP ESAL TRAFFIC $(W_{18})_{RUT}$ | (8) SEASONAL DAMAGE $W_{18}/W_{18})_{RUT}$ |
| WINTER (FROZEN | 20,000 | 30,000 | 9,125 | 70,000 | 0.13 | 400,000 | 0.02 |
| SPRING/THAW (SATURATED) | 1,500 | 30,000 | 4,563 | 4,200 | 1.09 | 7,000 | 0.65 |
| SPRING/FALL (WET) | 3,300 | 30,000 | 9,125 | 12,000 | 0.76 | 11,000 | 0.83 |
| SUMMER (DRY) | 4,900 | 30,000 | 13,687 | 13,500 | 1.01 | 16,000 | 0.86 |
| | | TOTAL TRAFFIC = | 36,500 | TOTAL DAMAGE = | 2.99 | TOTAL DAMAGE = | 2.36 |

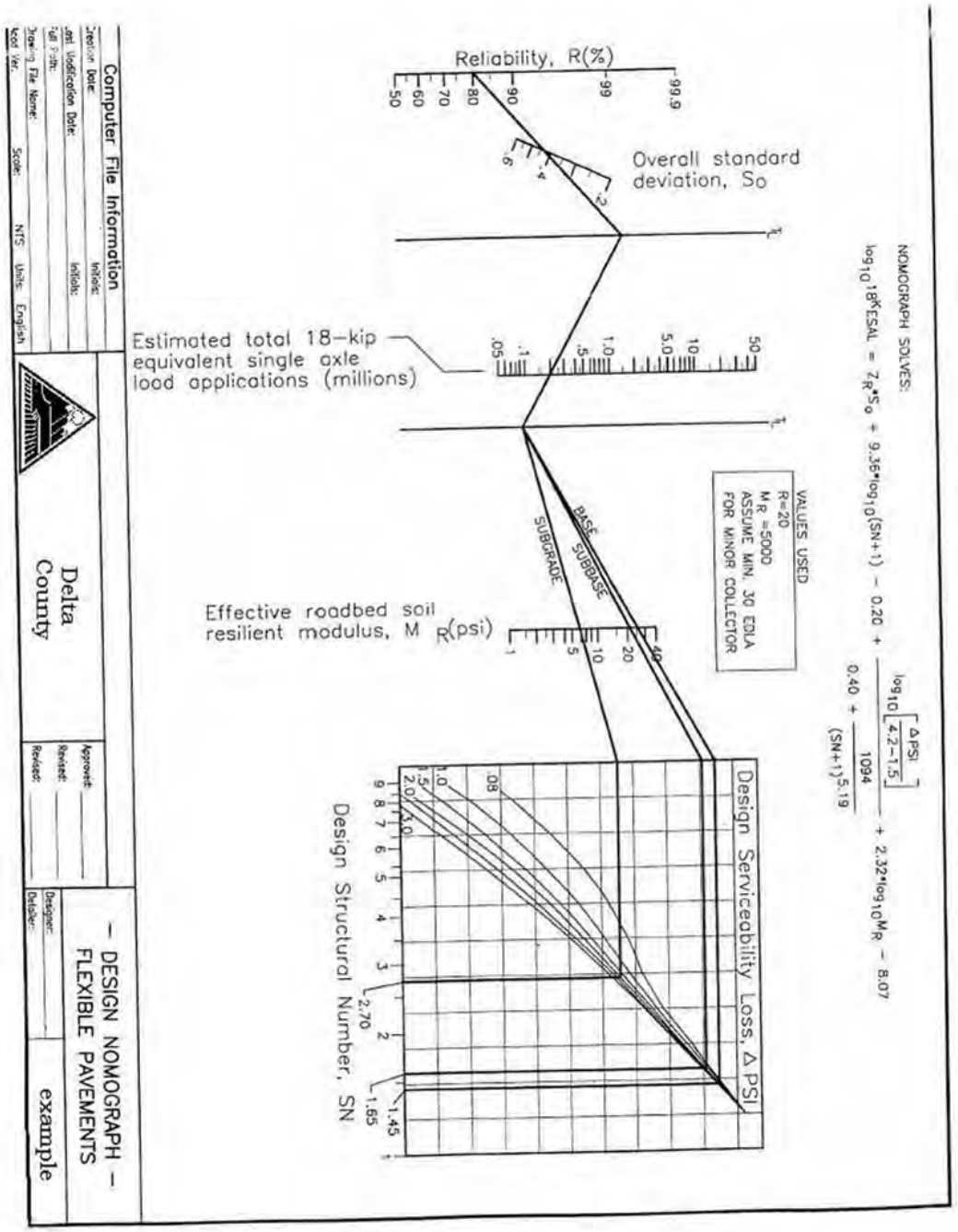
## EXAMPLE ASSUMING 10 INCHES BASE COURSE

| TRIAL BASE THICKNESS, DBS, (INCHES) _____10_____ | | | | SERVICEABILITY CRITERIA PSI =_____3_____ | | RUTTING CRITREIA RD (INCHES_____2____ | |
|---|---|---|---|---|---|---|---|
| (1) SEASON (ROADBED MOISTURE CONDITION) | (2) ROADBED RESILIENT MODULUS $M_R$ (psi) | (3) BASE ELASTIC MODULUS $E_{BS}$ (psi) | (4) PROJECTED 18-KIP ESAL TRAFFIC $W_{18}$ | (5) ALLOWABLE 18-KIP ESAL TRAFFIC $W_{18}$(psi) | (6) SEASONAL DAMAGE $W_{18}/W_{18}$(psi) | (7) ALLOWABLE 18-KIP ESAL TRAFFIC $(W_{18})_{RUT}$ | (8) SEASONAL DAMAGE $W_{18}/W_{18})_{RUT}$ |
| WINTER (FROZEN | 20,000 | 30,000 | 9,125 | 120,000 | 0.08 | 400,000 | 0.02 |
| SPRING/THAW (SATURATED) | 1,500 | 30,000 | 4,563 | 8,000 | 0.57 | 11,00 | 0.41 |
| SPRING/FALL (WET) | 3,300 | 30,000 | 9,125 | 20,000 | 0.46 | 21,000 | 0.43 |
| SUMMER (DRY) | 4,900 | 30,000 | 13,687 | 28,000 | 0.49 | 28,000 | 0.49 |
| | | TOTAL TRAFFIC = | 36,500 | TOTAL DAMAGE = | 1.60 | TOTAL DAMAGE = | 1.35 |

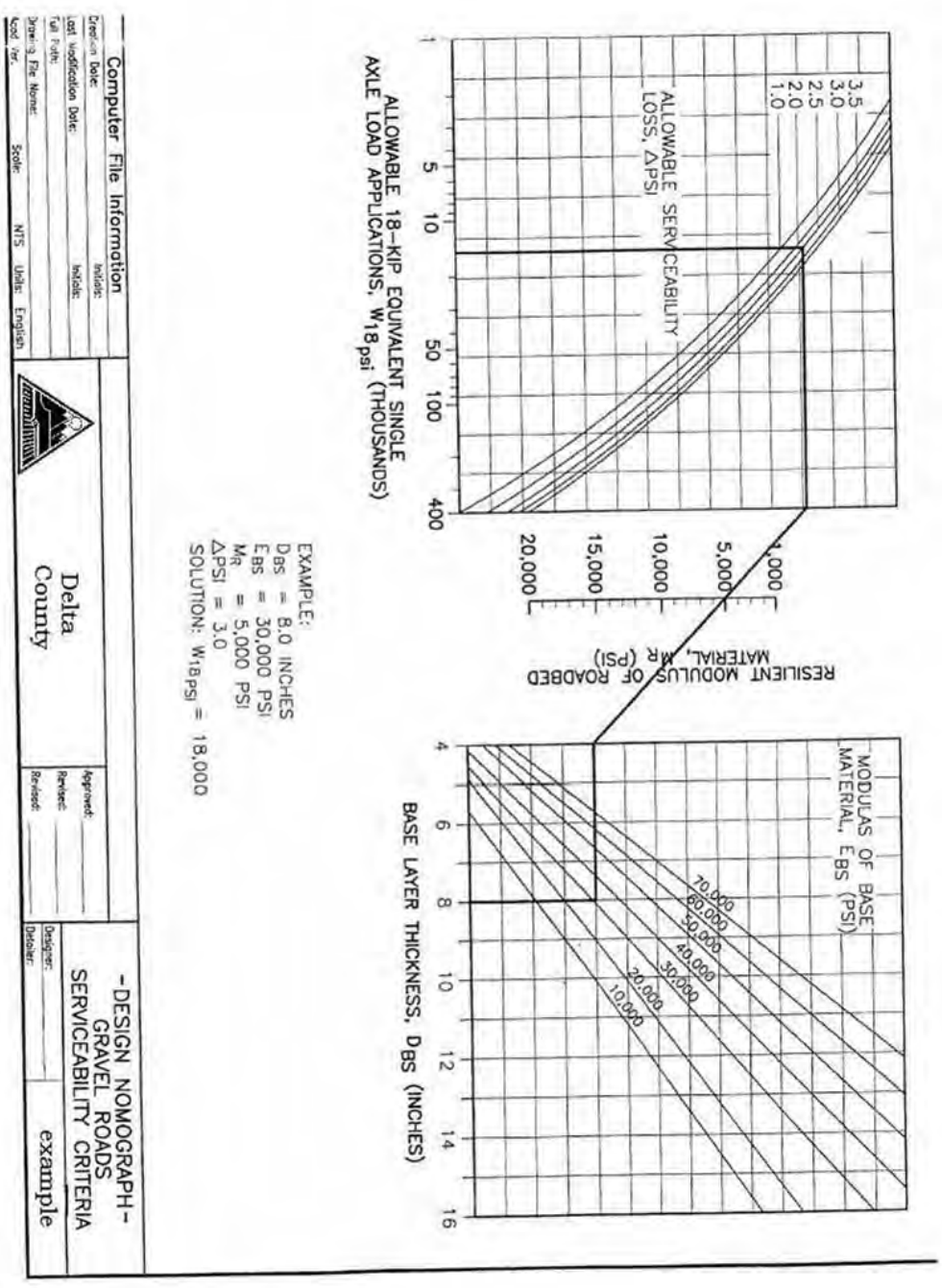
## EXAMPLE ASUMMING 12 INCHES BASE COURSE

| TRIAL BASE THICKNESS, DBS, (INCHES) _____12_____ | | | | SERVICEABILITY CRITERIA PSI =_____3_____ | | RUTTING CRITREIA RD (INCHES_____2____ | |
|---|---|---|---|---|---|---|---|
| (1) SEASON (ROADBED MOISTURE CONDITION) | (2) ROADBED RESILIENT MODULUS $M_R$ (psi) | (3) BASE ELASTIC MODULUS $E_{BS}$ (psi) | (4) PROJECTED 18-KIP ESAL TRAFFIC $W_{18}$ | (5) ALLOWABLE 18-KIP ESAL TRAFFIC $W_{18}$(psi) | (6) SEASONAL DAMAGE $W_{18}/W_{18}$(psi) | (7) ALLOWABLE 18-KIP ESAL TRAFFIC $(W_{18})_{RUT}$ | (8) SEASONAL DAMAGE $W_{18}/W_{18})_{RUT}$ |
| WINTER (FROZEN | 20,000 | 30,000 | 9,125 | 200,000 | 0.05 | 400,000 | 0.02 |
| SPRING/THAW (SATURATED) | 1,500 | 30,000 | 4,563 | 18,000 | 0.25 | 22,00 | 0.21 |
| SPRING/FALL (WET) | 3,300 | 30,000 | 9,125 | 30,000 | 0.30 | 31,000 | 0.29 |
| SUMMER (DRY) | 4,900 | 30,000 | 13,687 | 40,000 | 0.34 | 45,000 | 0.30 |
| | | TOTAL TRAFFIC = | 36,500 | TOTAL DAMAGE = | 0.94 | TOTAL DAMAGE = | 0.82 |

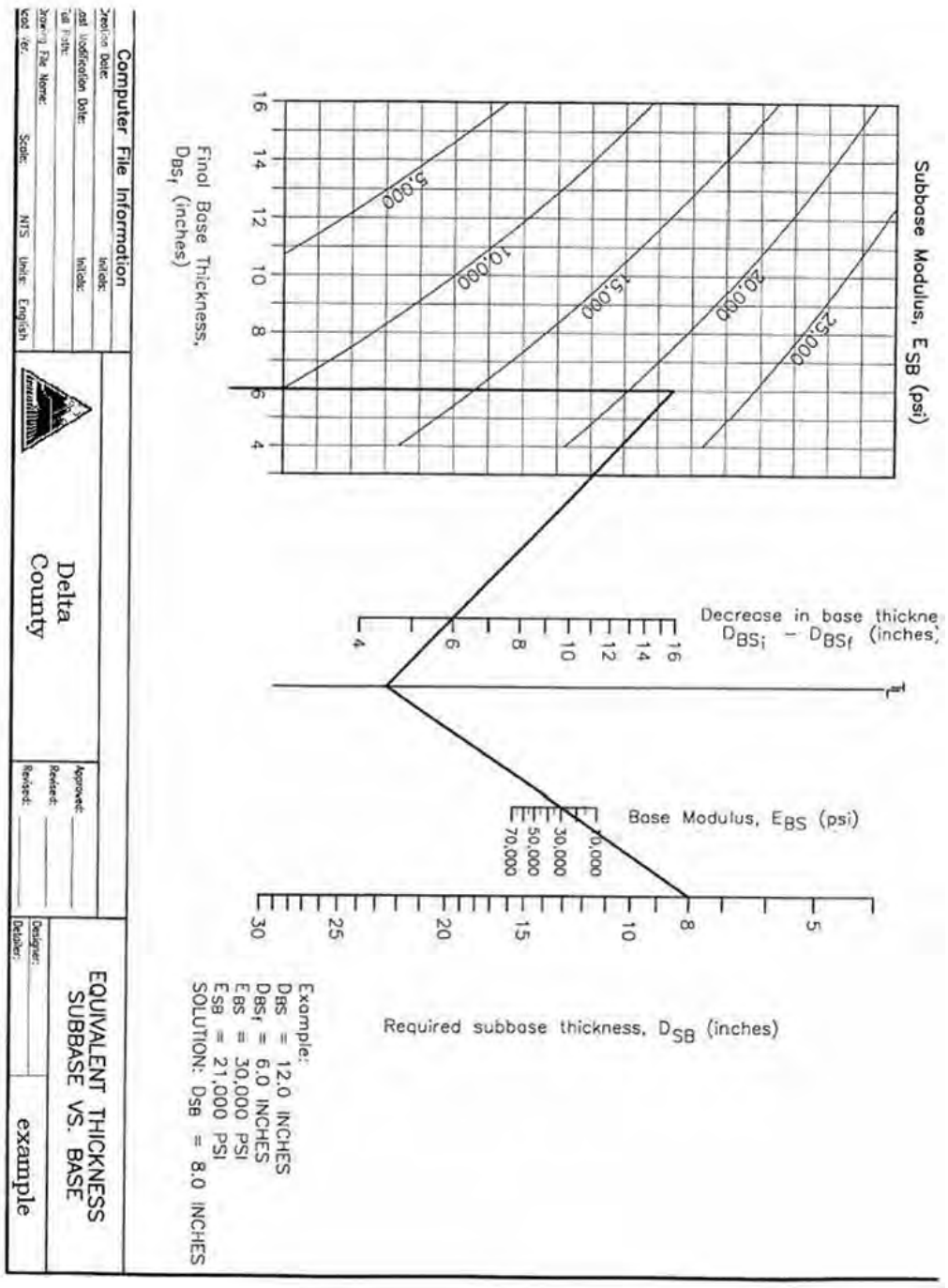
## Design Nomograph – Flexible Pavement Chart



Design Nomograph
Gravel Roads Serviceability Criteria



Equivalent Thickness Graph
Sub-base vs. Base



Graph
Total Damage vs. Layer Thickness