Kimley»Horn

June 22, 2015

Ms. Janet Tutt, District Manager
Village Community Development Districts
984 Old Mill Run
The Villages, Florida 32162

**RE:** ***Villages Multi-Use Trail Edge Line Marking and Median Treatment Evaluations***
***Kimley-Horn Project No. 142202013***

Dear Ms. Tutt:

Kimley-Horn was retained by the SLCDD on behalf of the VCDD's under Individual Project Order Number 2015-1 to evaluate the suitability of edge line marking and center landscape median marking treatments on the Villages Multi-Use Trails. The evaluations and recommendations contained in this report are based on guidance provided in the Manual on Uniform Traffic Control Devices (MUTCD) 2009, Florida Department of Transportation (FDOT) Greenbook, FDOT Design Standards for Roadway and Bridge Construction, and other applicable professional publications related to roadway and multi-use trail design.

The Multi-Use Trail system is unique in that it provides a paved travel way for golf carts, bicyclists, and pedestrians and has characteristics similar but not exclusive to both roadway and bicycle path facilities. The Multi-Use Trails have been designed to accommodate all users of the trail simultaneously. Engineering judgement is required when applying the standards and guidelines provided in the MUTCD and FDOT references to the Multi-Use Trail system.

Where applicable, specific MUTCD warrant criteria or guidance is presented related to the specific operational characteristics of the Multi-Use Trails. The MUTCD references are provided in bold font, with the application or recommendation for the Multi-Use Trails provided below each reference.

- A referenced Standard in the MUTCD is a statement of required, mandatory, or prohibitive practice.
- A referenced Guidance is a statement of recommendation that is not a mandatory application.
- A referenced Option is a statement of practice that is permissible, but is neither a requirement nor recommendation.
- Support is additional information related to the Standard, Guidance, or Option.

Three specific pavement marking concepts have been evaluated, as requested by the VCDD boards.

1. The addition of pavement markings at the center landscape medians within the existing Multi-Use Trails.
2. The addition of an edge line pavement marking on the outside edges of the existing Multi-Use Trails.
3. The incorporation of reflective pavement markings (RPM's) in either of the above two concepts.

# EXISTING CONDITIONS

## A. Physical Characteristics

The Villages Multi-Use Trail system includes approximately 42 miles of paved trails. The trails generally include a 15.5-feet wide asphalt surface, with a 6-inch concrete curb on either side. There are some variations in these widths in areas where geometric constraints exist. The Multi-Use Trails are intended for bi-directional travel for golf carts, bicyclists, and pedestrians. There is no edge line marking on the existing trails. There are centerline RPM's and/or centerline skip marking on specific locations of trail where the pavement is narrow or where geometric constraints warrant specific delineation of travel lanes. Median treatment for landscape medians within the trail have inconsistent treatments that include RPM's, marking, and reflective nose ends. A centerline yellow skip-stripe has recently been added to the Multi-Use Trail system within District 4.

## B. Historic Crash Data

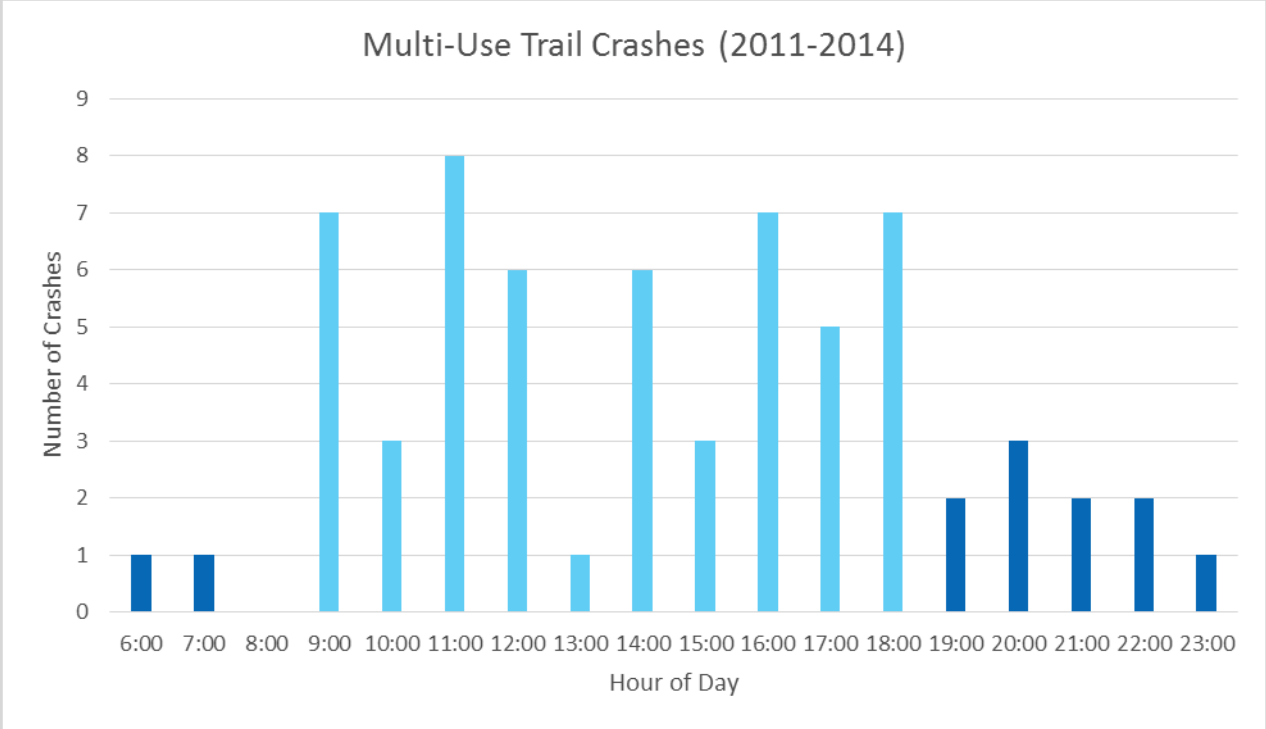
Historic crash data from years 2011 through 2014 was obtained from the Villages Public Safety Department (VPSD). This data represents a record of crashes where the VPSD responded to the crash. The VPSD responded to 340 golf cart crashes over the four year period. Sixty-five of the 340 reported golf cart crashes occurred on the Multi-Use Trail system, with the others occurring on commercial and residential streets, parking areas, etc. Of the 65 crashes reported on the Multi-Use Trail system, 44 were reported as injury crashes.

Because Kimley-Horn was directed by the VCDD that one of the primary concerns for travelers in golf carts is nighttime visibility we further reviewed the VPSD data to determine the number of crashes that occurred at night. Twelve crashes were reported on the Multi-Use Trail system between years 2011 and 2014 occurred under nighttime and dusk conditions, between the hours of 7PM and 8AM. This equates to an average of 3 crashes per year occurring during dusk or nighttime hours over approximately 84 miles of Multi-Use Trails, which includes both directions of travel. The reported causes of these crashes varied widely.

Fifty-three of the 65 crashes reported on the Multi-Use Trail system between 2011 and 2014 occurred between the daytime hours of 9AM and 7PM. There was an average of 13.25 crashes reported per year during daylight hours.

Exhibit 1 illustrates the number of crashes per hour of day over the four year period as reported by the VPSD.

*Exhibit 1: Number of Multi-Use Trail Crashes by Time of Day*




# 1. PAVEMENT MARKING EVALUATION

## A. Center Landscape Median Treatment

Raised medians and curbs of islands that are located in the line of traffic flow serve to channel traffic to the right of the obstruction and/or landscape median. The MUTCD addresses standard treatment of curb markings for raised medians and approach markings for obstructions in roadway applications in Section 3B.23 and 3B.10. The MUTCD also provides recommended treatment of marking for obstructions within a bicycle path in Section 9C.06. The AASHTO Guide for the Development of Bicycle Facilities provides recommended obstruction marking for bicycle facilities consistent with the MUTCD guidance. The FDOT Design Standards provide design details for pavement markings for traffic separation for roadway applications.

There are numerous locations along the Multi-Use Trail system where landscape islands are present in the center of the path. The treatment for the landscape islands includes roadway markings, RPM's, and reflective nose ends, but the application is inconsistent throughout the Multi-Use Trails.

## 1. Landscape Median Marking Guidance

The MUTCD provides guidance and application criteria for the use of marking on approach to medians and obstructions for roadway and bicycle applications. The warrants are provided below, along with criteria specific to the Multi-Use Trail application.

***"Standard: Where curbs are marked for delineation or visibility purposes, the colors shall comply with the general principles of markings (see Section 3A.05)."***

Any centerline marking around channelizing islands for separation of traffic flow in opposite directions should be yellow per Section 3A.05.

***"Guidance: Retroreflective solid yellow markings should be placed on the approach ends of raised medians and curbs of islands that are located in the line of traffic flow where the curb serves to channel traffic to the right of the obstruction. Retroreflective solid white markings should be used when traffic is permitted to pass on either side of the island."***

If installed, retroreflective markings placed on the approach ends of the curbs of landscaping islands should be yellow where traffic flow is directed to the right of the island, which is the case on the Multi-Use Trail system.

***"Support: Where the curbs of the islands become parallel to the direction of traffic flow, it is not necessary to mark the curbs unless an engineering study indicates the need for this type of delineation."***

The island curbing on the Multi-Use Trail is parallel to the direction of traffic flow, and therefore it is not necessary to mark the curbs.

***"Option: Retroreflective or internally illuminated raised pavement markers of the appropriate color may be placed on the pavement in front of the curb and/or on the top of curbed as of raised medians and curbs of islands, as a supplement to or substitute for retroreflective curb markings used for delineation."***

Yellow RPM's may be used in the pavement in front of the curb or on top of the curb on the approach end to the median as a supplement or substitute to retroreflective curb markings. Yellow RPM's may be used adjacent to the curb parallel to the direction of travel.

***"Option: If traffic is required to pass only to the right of the obstruction, yellow diagonal crosshatch markings (see Section 3B.24) may be placed in the flush median area between the no-passing zone markings as shown in Drawings A and B of Figure 3B-15. Other markings, such as yellow delineators, yellow channelizing devices, yellow raised pavement markers, and white crosswalk pavement markings, may also be placed in the flush median area."***

Yellow diagonal crosshatch markings are not recommended, but can be included in the flush median area on approach to the landscape medians. If installed, marking on approach to the landscape medians shall consist of marking according to the MUTCD standards and FDO Design Standards.

### 2. Landscape Median Marking Options Summary

A consistent center landscape median treatment should be implemented on the Multi-Use Trails. Taking into consideration the above guidance and standards, the recommended detail for landscape median marking on the Multi-Use Trails is shown in the attached Figure 1. Yellow diagonal crosshatch markings are not necessary or recommended on approach to the landscape median.

## B. Edge Line Marking

Edge line marking is solid longitudinal lines used to delineate the outside edge of a paved travel way. Per MUTCD Section 3A.05, when white markings for longitudinal lines are used, they shall delineate the right-hand edge of the roadway. Per Section 3B.06, right edge line pavement marking shall consist of a normal solid white line to delineate the right-hand edge of the roadway if used. A normal longitudinal line shall be 4 inches to 6 inches wide. The FDOT Greenbook, AASHTO Guide for the Development of Bicycle Facilities, AASHTO Policy on Geometric Design of Highways and Streets, and FDOT Design Standards reference the guidelines of the MUTCD as the governing guidelines for Multi-Use Trail pavement markings.

### 1. Edge Line Marking Warrants

The MUTCD provides warrants and guidance for the use of edge line marking in roadway applications in Section 3B.06 and Section 3B.07. The applicable warrants and guidance are provided below, along with criteria specific to the Multi-Use Trail application.

***"Standard: Edge line markings shall be placed on paved streets or highways with the following characteristics:***

***A. Freeways,***

***B. Expressways, and***

***C. Rural arterials with a traveled way of 20 feet or more in width and an ADT of 6,000 vehicles per day or greater."***

The design and function of the Multi-Use Trails are similar in characteristics with a local roadway, and are therefore not consistent with the design and function of freeways, expressways, or rural arterials. Therefore, the above warrant criteria is not met.

***"Guidance: Edge line markings should be placed on paved streets or highways with the following characteristics:***

***A. Rural arterials and collectors with a traveled way of 20 feet or more in width and an ADT of 3,000 vehicles per day or greater."***

The design and function of the Multi-Use Trails are more consistent with local roadways, and are therefore not consistent with the design and function of rural arterial or collector roadways. The traveled way of the Multi-Use Trail is 15.5 feet, which is less than the 20 feet in width referenced. Therefore, the above guidance criteria is not met.

***"B. At other paved streets and highways where an engineering study indicates a need for edge line markings."***

The very low frequency of approximately 3 crashes per year over 84 miles of Multi-Use Trails occurring during dusk or nighttime conditions does not indicate a crash trend that would be correctable through improved visibility by installation of edge line marking. This engineering study does not show an engineering warrant that is met for requiring the installation of edge line marking on the Multi-Use Trails. The above guidance criteria is not met.

***"C. Edge line markings should not be placed where an engineering study or engineering judgment indicates that providing them is likely to decrease safety."***

Although edge line marking is not warranted, engineering judgement does not indicate that placing edge line marking is likely to decrease safety. Installation of edge lines would not violate this guidance.

***"Option: Edge line markings may be placed on streets and highways with or without center line markings."***

If installed, edge lines may be placed without center line markings. A majority of the Multi-Use Trail system does not include centerline marking. The lack of centerline marking does not preclude the ability to install edge line markings.

***"Option: Edge line markings may be excluded, based on engineering judgment, for reasons such as if the traveled way edges are delineated by curbs, parking, or other markings."***

The travel way edges of the Multi-Use Trails are delineated by curbs. . One of the purposes of providing curbing on the Multi-Use Trail system is to provide a visible edge between the pavement and the grass. Because the curbing is present, edge line markings could be excluded based on engineering judgment even if other warrant criteria in the MUTCD were to be met.

***"Support: Edge line markings have unique value as visual references to guide road users during adverse weather and visibility conditions."***

Edge line markings are not warranted or recommended by this study. However, if they are installed they would not decrease safety and may serve to provide additional visual guidance during adverse weather and visibility conditions.

### 2. Edge Line Marking Options Summary

Edge line marking is not required by the warrant criteria provided in the MUTCD. In addition, the VPSD crash data shows a very low crash frequency during nighttime hours and does not indicate a crash trend that would be corrected by the installation of edge line pavement markings.

## C. Raised Pavement Markers (RPM's)

A Raised Pavement Marker (RPM) is a device mounted on or in a road surface that is intended to be used as a positioning guide. A RPM can be placed with other longitudinal markings or can supplement or substitute for other markings. There are three colors of RPMs for use in roadway applications; white, yellow, and red. White and yellow RPMs have the same meaning as pavement markings of the same colors. Red retroreflective RPMs convey the message "wrong way".

RPM's are currently used along the Multi-Use Trail system in locations where geometric constraints exist that require delineation between opposing directions of travel. For example, RPM's are used in areas where the Multi-Use Trail narrows or around sharp curves and tunnels. RPM's are also used on the Multi-Use Trails along edge curbing at specific locations where geometric conditions present a need for additional marking or delineation. The MUTCD provides standards for use of RPM's and guidance on the use for each situation. The standards and guidance for use are summarized in the following sections.

According to the Federal Highway Administration (FHWA) Roadway Delineation Practices Handbook, RPM's have the following advantages over standard painted markings:

- Retroreflective RPMs provide increased retroreflectivity under wet weather conditions.
- Both retroreflective and non-retroreflective RPMs are more durable than painted lines. Replacement is much less frequent and repainting operations under heavy traffic conditions can often be avoided.
- The vehicle vibration and audible tone produced by vehicles crossing over the RPMs creates a secondary warning.
- The capability of providing directional control of retro reflected color permits their use in conveying a wrong way message.

## 1. RPM Use Standards

The standards for RPM use in roadway applications are provided in Section 3B.11 through Section 3B.14 of the MUTCD. The applicable standard, and supporting information for use on the Multi-Use Trails is provided below.

***"Standard: The color of raised pavement markers under both daylight and nighttime conditions shall conform to the color of the marking for which they serve as a positioning guide, or for which they supplement or substitute.***

***Guidance: Non-retroreflective raised pavement markers should not be used alone, without supplemental retroreflective or internally illuminated markers, as a substitute for other types of pavement markings. Directional configurations should be used to maximize correct information and to minimize confusing information provided to the road user. Directional configurations also should be used to avoid confusion resulting from visibility of markers that do not apply to the road user. The spacing of raised pavement markers used to supplement or substitute for other types of longitudinal markings should correspond with the pattern of broken lines for which the markers supplement or substitute."***

If installed, RPM's in the center of the Multi-Use Trail should be yellow/yellow to supplement or substitute yellow centerline marking. If installed, RPM's on the outside edge of the Multi-Use Trail should be white to supplement or substitute white edge line marking.

***"Guidance: Raised pavement markers should not supplement right-hand edge lines unless an engineering study or engineering judgment indicates the benefits of enhanced delineation of a curve or other location would outweigh possible impacts on bicycles using the shoulder, and the spacing of raised pavement markers on the right-hand edge is close enough to avoid misinterpretation as a broken line during wet night conditions".***

RPM's should not be installed as a supplement to right-hand edge lines because of the impact to bicycles and pedestrians utilizing the outside edge of the Multi-Use Trail.

***"Option: Raised pavement markers also may be used to supplement other markings such as channelizing islands, gore areas, approaches to obstructions, or wrong-way arrows. To improve the visibility of horizontal curves, center lines may be supplemented with retroreflective or internally illuminated raised pavement markers for the entire curved section as well as for a distance in advance of the curve that approximates 5 seconds of travel time."***

RPM's can be used to supplement markings on approach to landscape medians on the Multi-Use Trails and also in the center of the Multi-Use Trails to improve visibility on sharp curves. This is the current practice on the Multi-Use Trail system.

***"Option: Retroreflective or internally illuminated raised pavement markers, or non-retroreflective raised pavement markers supplemented by retroreflective or internally illuminated markers, may be substituted for markings of other types.***

***Guidance: If used, the pattern of the raised pavement markers should simulate the pattern of the markings for which they substitute."***

RPM's can be used in lieu of pavement markings. If used, the pattern and color of the RPM's should simulate the pattern of the markings for which they substitute.

### 2. RPM Use Options Summary

Retroreflective RPMs provide increased retroreflectivity under wet weather conditions. Both retroreflective and non-retroreflective RPMs are more durable than painted lines, based on guidelines published by the FHWA. RPM's can be used to supplement or substitute marking as described in the MUTCD standards above. RPM's should not be used on the right-hand edge of the Multi-Use Trail due to the impact on bicycle and pedestrian safety.

## 2. CONCLUSION AND RECOMMENDATIONS

Inclusion of marking on approach to center landscape medians, edge line pavement marking, and incorporation of RPM's on the Villages Multi-Use Trails have been evaluated based on warrant criteria and guidance provided in the MUTCD and applicable portions of other FDOT, FHWA, and AASHTO references related to roadway and bicycle applications. The Multi-Use Trail system is unique in that it provides a paved travel way for golf carts, bicyclists, and pedestrians and has characteristics similar but not exclusive to both roadway and bicycle path facilities. Engineering judgement has been utilized in application of the warrant criteria and guidance to develop the recommendations provided below.

### A. Recommendations for Landscape Median Treatment

Consistent pavement markings should be applied on the approach to center landscape medians within the Multi-Use Trail system. Many options are allowable based on the guidance within the MUTCD. Engineering judgment is required to fit a design solution to the Villages Multi Use Trails. The recommended treatment is provided in Figure 1.

### B. Recommendations for Edge Line Marking

After analysis of the characteristics of the Multi-Use Trail based on the MUTCD warrant criteria, this engineering study does not show an engineering warrant for installation of edge line marking on the Multi-Use Trail. The historic crash data demonstrates a low frequency of nighttime crashes, and does not indicate a crash trend due to adverse nighttime visibility. Edge line marking is not recommended as there is no engineering justification requiring its installation.

If the VCDD's were to proceed with the installation of edge line pavement markings despite the lack of MUTCD warrants or correctable crash trend data, the markings should follow the detail provided in the attached Figure 2. While we have determined that there is no engineering warrant or justification for installing edge line pavement markings we do not believe that they would decrease safety on the Multi Use Trails if installed. The current FDOT average cost for 4-inch thermoplastic marking is approximately $3,500 per net mile. There are approximately 84 net miles of travel lane on the Multi-Use Trail system.

## C. Recommendations for RPM Use

RPM's can be used to supplement or substitute any pavement marking as outlined in the MUTCD. RPM's are recommended for use on approach to landscape medians. RPM's are recommended at locations where geometric constraints warrant specific delineation of travel lanes, as shown in the attached Figure 3, such as tight curves and tunnel entrances. RPM's are not recommended for use on the right-hand edge of the Multi-Use Trail due to the potential impact to pedestrian and bicycle safety.

Finally, any application of markings on approach to landscape medians, edge line marking, and/or RPM's should be implemented consistently on the Multi-Use Trail system throughout the Villages to provide for orderly and uniform traffic control and messaging.

Please feel free to contact me with any questions on this material or recommendations. I will be present to discuss and answer any board member questions at the July 6th PWAC and Multi-Modal Path Group Meeting.

Sincerely,

Richard V. Busche, P.E., CFM
Senior Vice President

RVB/ALG/aep

Attachments: Figure 1 – Recommended Median Treatment
Figure 2 – Edge Line Option Detail
Figure 3 – RPM Placement at Geometrically Constrained Location

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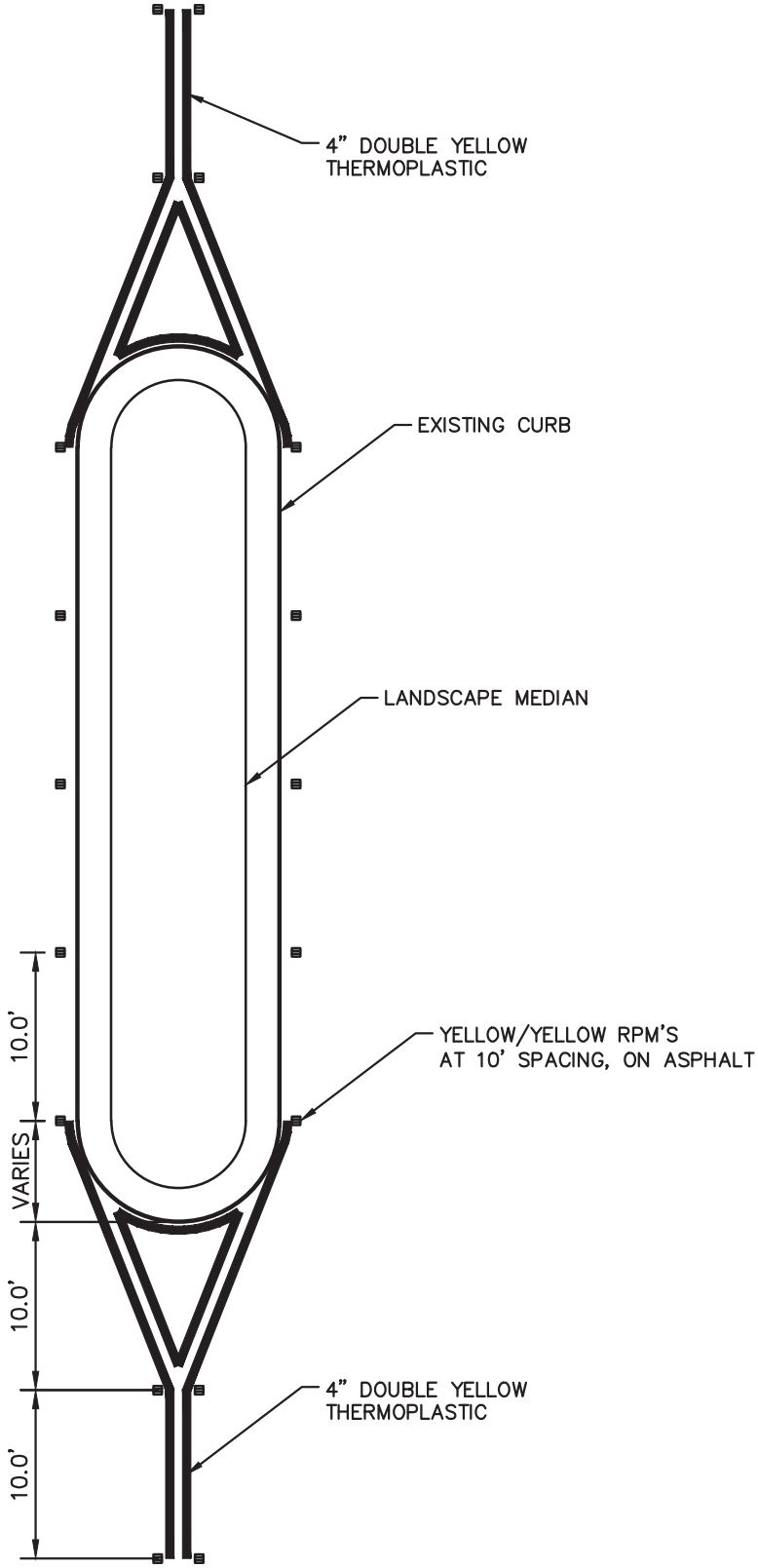
# FIGURE 1
## RECOMMENDED MEDIAN TREATMENT




Drawing name: K:\OCA_Civil\142202013 – MUT Striping\CADD\Exhibit\MUT Marking Exhibit.dwg FIGURE 1 Jun 12, 2015 12:06pm by: caitlin.smith



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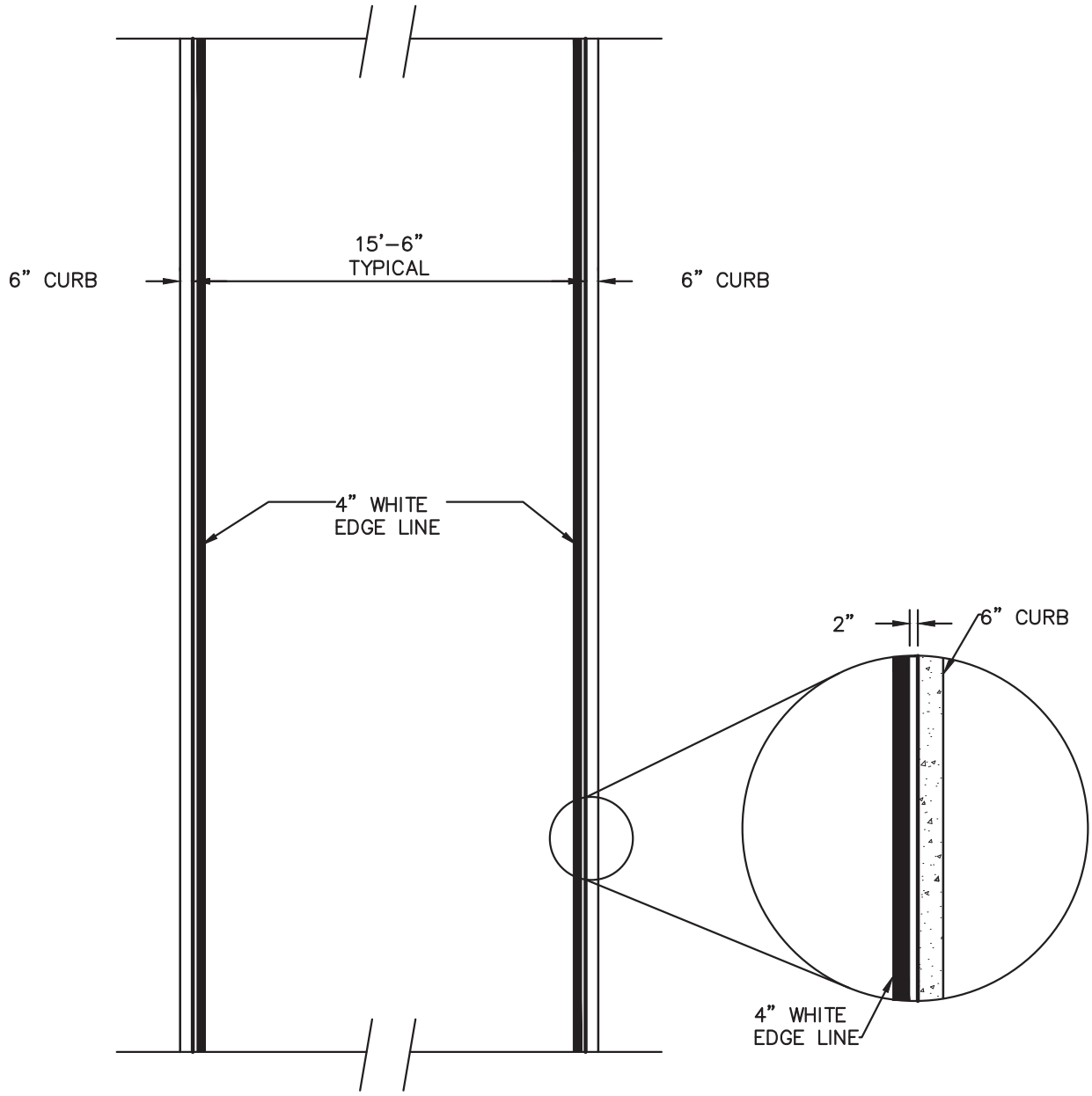
|---|---|---|---|---|
| DATE JUNE 2015<br>PROJECT NO. 142202013<br>SHEET NUMBER 01 | MULTI-USE TRAIL MARKING EVALUATION | SCALE N.T.S.<br>DESIGNED BY KHA<br>DRAWN BY DSC<br>CHECKED BY ALG | DESIGN ENGINEER: RICHARD V. BUSCHE, P.E.<br>FLORIDA P.E. LICENSE NUMBER: 58568<br>DATE: | Kimley»Horn<br><br>1823 SE FORT KING STREET, SUITE 200, OCALA, FL 34471<br>PHONE: 352-438-3000<br>WWW.KIMLEY-HORN.COM CA 00000696 |

# FIGURE 2
## EDGE LINE OPTION DETAIL




NOTE: OPTIONAL 4" WHITE
THERMOPLASTIC EDGE LINE
2" FROM EDGE OF CURB

Drawing name: K:\OCA_Civil\142202013 – MUT Striping\CADD\Exhibit\MUT Marking Exhibit.dwg FIGURE 2 Jun 12, 2015 12:06pm by: caitlin.smith



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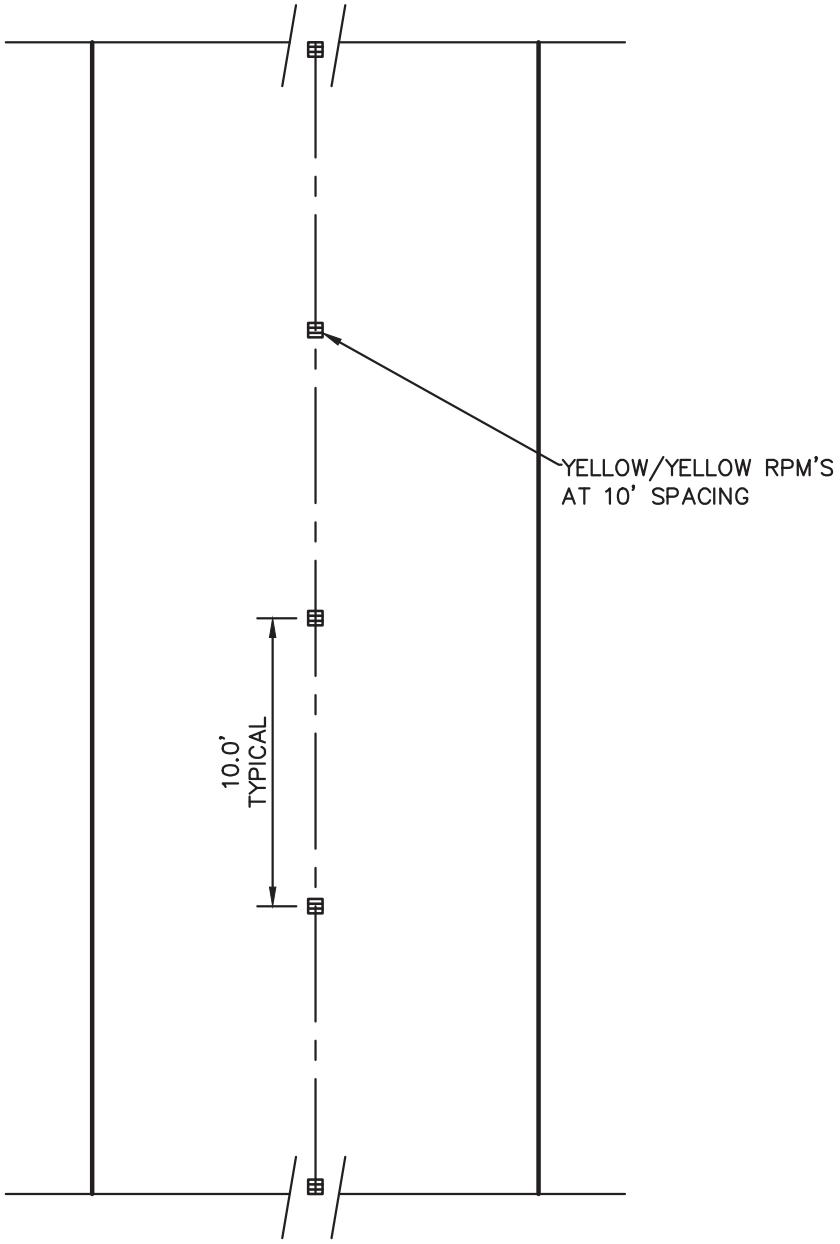
|---|---|---|---|---|
| DATE JUNE 2015<br>PROJECT NO. 142202013<br>SHEET NUMBER 02 | MULTI-USE TRAIL MARKING EVALUATION | SCALE N.T.S.<br>DESIGNED BY KHA<br>DRAWN BY DSC<br>CHECKED BY ALG | DESIGN ENGINEER: RICHARD V. BUSCHE, P.E.<br>FLORIDA P.E. LICENSE NUMBER: 58568<br>DATE: | Kimley»Horn<br><br>1823 SE FORT KING STREET, SUITE 200, OCALA, FL 34471<br>PHONE: 352-438-3000<br>WWW.KIMLEY-HORN.COM CA 00000696 |

# FIGURE 3

## RPM PLACEMENT AT GEOMETRICALLY CONSTRAINED LOCATION




NOTE: INSTALL YELLOW/YELLOW RPM'S AT CENTERLINE OF MULTI-USE TRAIL ON 10' SPACINGS WHERE CONSTRAINED GEOMETRIC CONDITION WARRANTS (APPROACH TO CURVE, TUNNEL, NARROW TRAIL, ETC.)

Drawing name: K:\OCA_Civil\142202013 – MUT Striping\CADD\Exhibit\MUT Marking Exhibit.dwg FIGURE 3 Jun 12, 2015 12:06pm by: caitlin.smith



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|---|---|---|---|---|
| DATE JUNE 2015<br>PROJECT NO. 142202013<br>SHEET NUMBER 03 | MULTI-USE TRAIL MARKING EVALUATION | SCALE N.T.S.<br>DESIGNED BY KHA<br>DRAWN BY DSC<br>CHECKED BY ALG | DESIGN ENGINEER: RICHARD V. BUSCHE, P.E.<br>FLORIDA P.E. LICENSE NUMBER: 58568<br>DATE: | Kimley»Horn<br><br>1823 SE FORT KING STREET, SUITE 200, OCALA, FL 34471<br>PHONE: 352-438-3000<br>WWW.KIMLEY-HORN.COM CA 00000696 |