DESIGN REPORT

FOR

ZEPHYR COVE WATER QUALITY IMPROVEMENT PROJECT

ZEPHYR COVE, NEVADA

January 2017

PROFESSIONAL ENGINEER-STATE OF NEVADA
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Exp: 6/30/2017
CIVIL
2/6/2017
No. 20851

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1.0 INTRODUCTION

The goal of the Zephyr Cove Water Quality Improvement Project is to treat sediment and nutrient laden stormwater flows from US Highway 50 by re-routing flows to an infiltration basin located down slope and safely conveying any overflow to Lake Tahoe while minimizing beach erosion. The primary goal of the Zephyr Cove General Improvement District (ZCGID) Water Quality Improvement Project (WQIP) (Project) is to treat stormwater via infiltration before discharge to Lake Tahoe. From this goal, the following objectives were developed and used to guide the design process:

1. Develop a project that utilizes minimal structural components to treat stormwater before discharge to the Lake;
2. Develop a project that requires a minimal Operations & Maintenance budget;
3. Attempt to treat stormwater from multiple sources Nevada Department of Transportation (NDOT), ZCGID and Zephyr Cove Property Owners Association (ZCPOA)) and therefore incur economy of scale; and
4. Attempt to reduce other pollutants of concern like nitrogen and phosphorus.

The design plans and specifications were developed based on the preferred alternative (Alternative 2) described in the March 2016 Zephyr Cove Water Quality Improvement Project Alternatives Analysis Report as well as feedback received on the 75 and 90 Percent Plans (Appendix D). The project was split into two Phases to accommodate funding deadlines and permitting issues. Phase 1 was constructed in October 2016 and Phase 2 will be constructed in 2017. Heavy rains and sand erosion also necessitated repairs to Phase 1 during Phase 2.

1.1 PROJECT LOCATION

The Zephyr Cove Water Quality Improvement Project (Project) is located within Douglas County, in Zephyr Cove, Nevada, T13NR18E Sec10. The nearest cross streets are Highway 50 and Church Street. The Project encompasses private, state and federal property. See Figure 1 below for Project vicinity.

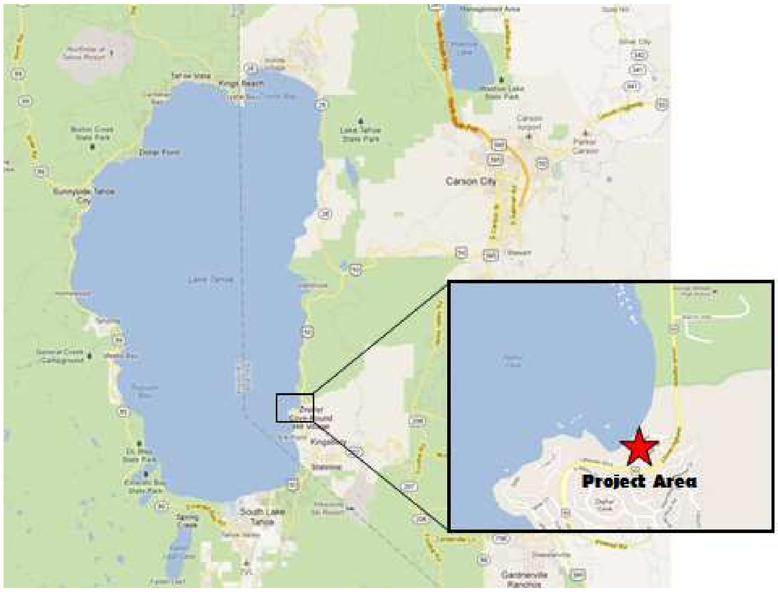

Figure 1. Project Area Location.

1.2 PROJECT FUNDING

The Project received funding from the US Forest Service (USFS), the Nevada Department of Transportation (NDOT), the Nevada Division of State Lands (NDSL) and the Nevada Division of Environmental Protection (NDEP). The funding amounts are listed in Table 1.

Table 1. Funders and Funding Amounts

Funder	Funding Amount
USFS	$300,000
NDOT	$350,000
NDSL	$150,000
NDEP	$105,705
Total	**$905,705**

Project partners include the funders and jurisdictions listed above as well as the following regulatory agencies and stakeholders: Zephyr Cove General Improvement District, Zephyr Cove Property Owners Association, Douglas County, the Nevada Division of Environmental Protection (NDEP), and the Tahoe Regional Planning Agency (TRPA).

2.0 EXISTING CONDITIONS

Zephyr Cove GID contains a residential neighborhood with single family dwellings on ¼ acre or smaller lots. The Project area also includes a portion of Highway 50 adjacent to and up gradient of the neighborhood, which produces a majority of the runoff and sediment loading. Zephyr Cove Resort, also adjacent to the neighborhood, is on land owned by the US Forest Service and leased to Aramark Corporation. The neighborhood and Highway 50 right of way is limited in area available for stormwater treatment. Currently, stormwater runoff originating from Highway 50 is collected and conveyed directly to the Lake via two outfalls in the Zephyr Cove neighborhood. The stormwater runs through multiple sediment traps and a vault, but these structures are undersized and are inefficient at retaining fine sediment particles (FSP) and nutrients, the pollutants of concern as identified in the Lake Tahoe Total Maximum Daily Load (TMDL).

2.1 LAND CAPABILITY

The USFS and TRPA developed the Bailey land capability system in the early 1970s based primarily on the official US Department of Agriculture (USDA) soils maps for the Tahoe Region (Bailey, 1974). Each soil type was assigned to a land capability class ranging from 1 to 7, with capability 1 being the most environmentally fragile and sensitive to development. Wherever land was found to be influenced by a stream or high groundwater, it was assigned to capability 1b, also known as "Stream Environment Zone" or SEZ. The Zephyr Cove GID WQIP Project is located within TRPA land capability classes 1A, 1B, 2, and 7. The 1b area is located in the beach area, closest to the lakeshore. Improvements are anticipated to be constructed in the 2 and 7 land capability classes along or adjacent to existing roadways. No improvements may be constructed within the TRPA-delineated backshore as shown the design plans.

2.2 EXISTING SOILS

The Natural Resources Conservation Service (NRCS) soil survey indicates that the Project area is located within soil map units 7412, 7422, and 7444. Soil unit 7412 is Cagwin-Rock outcrop complex, 15 to 30 percent slopes, extremely stony. Unit 7422 is Cassenai gravelly loamy coarse sand, 15 to 30 percent slopes, very stony. Lastly, unit 7444 is Christopher-Gefo complex, 0 to 5 percent slopes. See Figure 2 for soils map. The soil in the Project area is in either Hydrologic group A or B. Locations of infiltration features are planned on group A soils only, which are very fast draining soils.

Figure 2. Project Area NRCS Soil Map Units.

2.3 SUB-WATERSHEDS

Figure 3 displays the sub-watershed boundaries with drainage areas in acres and outfall locations. A detailed discussion of sub-watershed delineation is available in the March 2016 Alternatives Analysis Report.

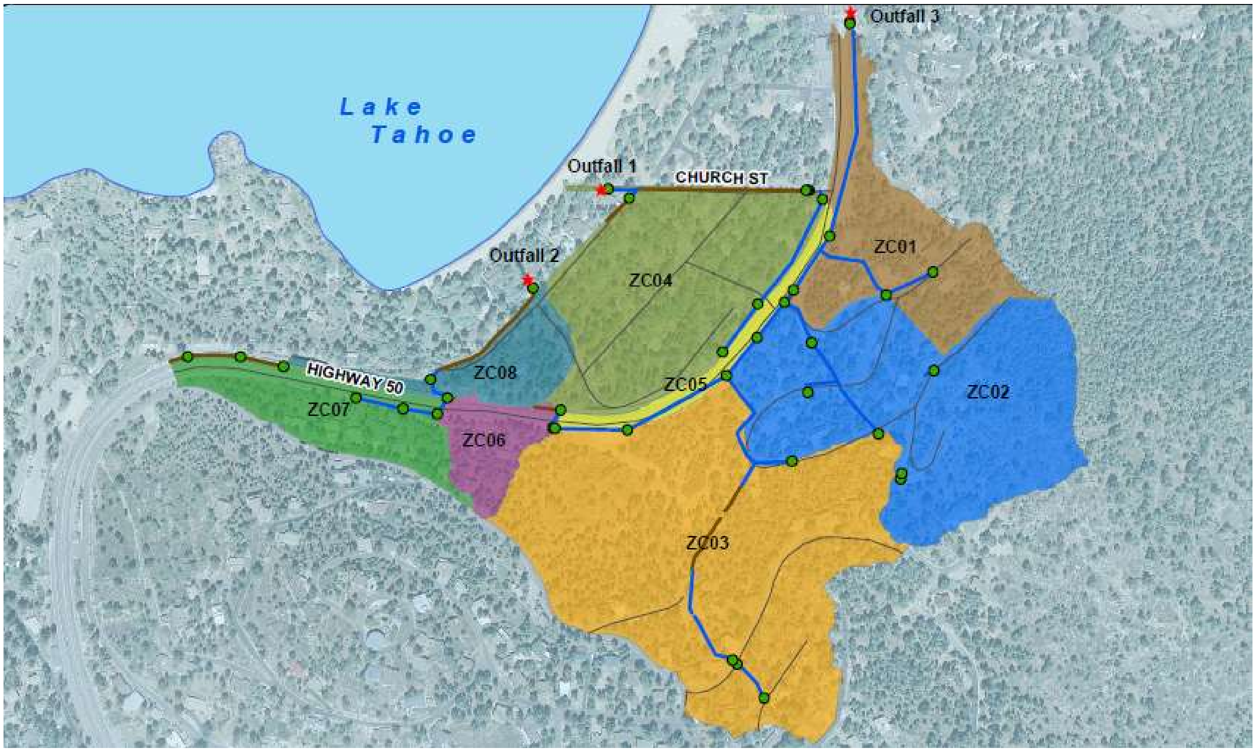

Figure 3. Project Sub-Watersheds.

2.4 DESIGN FLOWS

Design flows were calculated using the SCS method in the NRCS TR-55 Bulletin and utilizing HEC-HMS version 4.0. The contributing watershed to the Zephyr Cove GID WQIP project area is approximately 64 acres. The watershed was divided into eight (8) existing sub-watersheds based on outlet and proposed treatment locations to determine the peak flow and quantity of runoff for the 2, 25, and 100 year -24 hour storm events. The precipitation intensity, i, was determined using the National Oceanic and Atmospheric Administration's (NOAA's) Precipitation Frequency Data Server. The 25 year storm is the design storm for Project conveyance, meeting both NDOT and Douglas County Standards. All treatment facilities are designed to the maximum extent practicable. The design storm results for the outfalls in existing conditions are summarized below in Table 3. The HEC-HMS input and results of the volume peak flow for existing conditions and all alternatives are displayed in Appendix A: Revised Preliminary Hydrology (HEC-HMS).

Table 2. Existing Conditions Design Storm (25 year, 24 hour) HEC-HMS Results

Outfall	Peak Flow (cfs)	Volume (AF)
1: Church Street	1.5	0.5
2: Foothill Drive	3.2	1.2
3: USFS SEZ	6.2	3.8

3.0 DESIGN

The major design components of the project include an infiltration basin on USFS land, a change in stormwater conveyance along US Highway 50, and enhancements to the outfalls within the Zephyr Cove neighborhood. Construction of design features was separated into two phases due to permitting and funding requirements. Phase 1 was completed in the 2016 construction season and included the outfall enhancements design features. Phase 2 is anticipated to be completed in spring/summer of 2017.

3.1 PROPOSED BASIN

The project will install one water quality treatment infiltration basin at the corner of Church Street and Highway 50 (USFS Parcel 1318-10-000-002) and route stormwater from the adjacent Highway 50 catchment as well some additional upstream catchments to the proposed basin. The proposed infiltration basin will be offline; when it's at capacity, stormwater will bypass the basin and continue down the existing articulated block (AB) channel along Church Street. This is accomplished by setting the maximum ponding depth of the basin equal to the invert elevation of the bypass pipe. When the water in the basin reaches its capacity elevation (6269'), water flows to the outflow pipe and continues down a proposed pipe to the existing vaults and articulated block channel on Church Street. An off-line configuration assures the basin will use infiltration and not simply retention as a treatment method. Infiltration is one of the most cost effective and proven methods for treatment of FSP while retention has been shown to be ineffective. The infiltration basin will be approximately 9,000 square feet (total footprint) and will be designed to blend into the natural landscape by using native vegetation and ground cover and natural slopes. Because of the set elevation constraints of the existing overflow structures (vaults and AB channel on Church Street), a berm is necessary on the downhill side of the basin to achieve the grades necessary for off-line function of the basin. The basin extents as shown on the plans, keep the berm height at a maximum of approximately 4 feet with natural side slopes as required by USFS. The basin can capture approximately the 5 year, 1 hour storm or 0.6 inches of precipitation in one hour. Flows were calculated using HEC-HMS. See the Zephyr Cove Water Quality Improvement Project Alternatives Analysis Report for more information on drainage calculations and catchments.

Other design features of the proposed basin include a standpipe and overflow to a newly installed manhole that will flow to the existing 3 vaults upstream of the articulated block channel. This overflow is expected to function as an emergency overflow with the height of the standpipe being set at 6 inches above the offline elevation in the manhole (6269.5'). With this standpipe elevation, six inches of freeboard is maintained which meets Douglas County design requirements. A new wooden fence will also be installed to mask the basin from the adjacent Zephyr Cove Resort. Trees will be saved if possible for additional screening and aesthetics. Basin inflow, outflow, and capacity were calculated based on hydraulic grade lines and the Manning's equation. See Appendix A for calculations for the basin capacity and inflow and outflow elevations and capacities. A geotechnical investigation was performed by Marvin Davis and Associates in October of 2016. The results of the investigation were incorporated into the grading and berm design specification. The full memo has been attached to this report as Appendix E.

3.2 PROPOSED CONVEYANCE

The project area has three different Highway 50 sub-watersheds as indicated Figure 3, ZC05, ZC06, and ZC07. The connection of these Highway 50 catchments to the proposed basin requires the installation of 962 linear feet of conveyance pipe in the Highway 50 road shoulder. The shoulder of Highway 50 has utilities and a retaining wall with a moment slab that will prevent the installation of the NDOT required minimum storm drain diameter of 18 inches. NDOT has approved the exception of connecting the three drainage inlets using 14 inch Snaptite® HDPE. Unlike more rigid pipes, Snaptite® HDPE pipe can be installed around the existing road radius without the need for many additional drainage inlets. Snaptite® is also smooth and conveys water efficiently as the pipe only flows, in fact, at the 100 year flow, the pipe will flow at less than half full. The calculations for the pipe capacity are available in Appendix B.

The most upstream existing drainage inlet that the proposed pipe connects to is located in existing catchment ZC07. This inlet will be retrofitted with a wooden weir to split flows. Low flows will be diverted to the proposed basin while the overflow will run through the inlet's existing infrastructure leading to the Foothill Drive outfall (Outfall 2). The middle drainage inlet, located in existing catchment ZC06, does not need a weir as the existing outlet pipe is at the very top of the inlet. The proposed pipe connection will allow the middle inlet to send low flows to the proposed basin. If the middle drainage inlet is ever near full, the existing outlet pipe will activate as an overflow, sending high flows to where they are now currently received at Outfall 3. The third and downstream-most drainage inlet connected to the proposed pipe is located in existing catchment ZC05. This inlet is flow-through and does not have an overflow design. Existing downstream infrastructure was found to be adequate to receive additional flow (see Appendix B, Conveyance and Spread Calculations), however, the basin size limits the size of storm that can be treated and so a reasonable split elevation was chosen to limit flow to approximately the 5 year storm. The wooden design of the weir enables NDOT to easily change the height of the weir, if needed, based on monitoring the basin as well as each outfall. Wooden weirs have been used successfully in other locations like the City of Portland (Stormwater Management Manual, 2016).

3.3 PROPOSED OUTFALLS

While infiltration of stormwater in the proposed basin will result in a reduction of the overland flow which causes drastic beach erosion, some additional measures to prevent erosion were installed during Phase 1 at the two outfalls in the Zephyr Cove General Improvement District (GID) neighborhood. These improvements are on Zephyr Cove POA properties at the end of Church Street and the end of Foothill Drive. The outfall improvements described below were installed in October 2016, but large storms tested the installed improvements immediately and failures will require repair in Phase 2. These repairs are captured in the Phase 2 plans.

The outfall at the end of Church Street, where basin overflow will travel, received modifications to the existing infiltration vault to improve its drainage and a pipe and rock bowl to safely deliver the runoff to Lake Tahoe. The infiltration vault was thoroughly cleaned. A vertical curb was installed at the north end of the existing asphalt path to prevent vault overflow from spreading onto adjacent USFS land. The path was graded to slope towards the curb, preventing runoff onto the adjacent private property. At the end of the existing asphalt path, a flat rock channel was constructed to convey any overflow from the path and to simultaneously allow the public to access the beach without angular rock as a tripping and walking hazard. While this flat rock channel is in great condition, a portion of it will be reconstructed in Phase 2 adding a Class 150 rock mix between the pea gravel and the flat rock. This will provide additional protection against sand erosion, which at the very end was starting to undermine the channel. Downslope of the flat rock channel, a rock bowl was installed to dissipate the water's energy and disperse it. The rock bowl size and depth was designed using the Federal Highway Administration's HEC-14 and the bowl itself is in good condition. The rock bowl and subsequent rock lined channel were designed to have angular rock to resist the expected velocities from the pipe outlet. While the rock placed during Phase 1 was angular, the rock could have been placed in a way to better slow down the fast moving stormwater. The rock lined channel down slope of the rock bowl has dropped approximately one to two feet due to sand erosion. This channel will be repaired using a mix of pea gravel, Class 150 rock, and larger angular rock. More details on pipe, rock, channel, and basin sizing are provided in Appendix C, Outfall Calculations.

The outfall at the end of Foothill Drive has more constraints as the pavement receives vehicle traffic and a sewer force main as well as power, water, and gas lines are below the pavement. This outfall also has an existing infiltration vault. During Phase 1, a strip of super pervious pavers (Xeripave or equivalent) was installed to convey flow down the center of the existing path. Since the pavers are a course media, they resist the flow and help dissipate the water's energy before it reaches highly erodible beach sand. The path was also re-graded to create a "reverse crown" or a gradual V so the water effectively sheet flows toward the center of the V in higher flow events and stays away from historic rock walls and the community's pier. The V-configuration also protects the pervious pavers from snowplow damage. The design chosen avoids deep excavation and achieves a drivable surface with roughness to reduce flow velocities. The Xeripave pavers were chosen due to the lower cost and the potential enhanced infiltration ability. The increased roughness reduces average velocities from the peak 100 year, 24 hour flow approximately 25 percent as demonstrated in the calculations provided in Appendix C. The paver channel constructed during Phase 1 did function well under lower flows, but during the large storm events in October 2016, the concrete curb at the end of the channel was undermined with eroding sand beneath the flat rock channel installed at the terminus of the path. The proposed repair for Phase 2 will add concrete under the final 6 rows of pavers so that instead of flowing under the curb, stormwater will flow over the curb as designed and onto the rock lined channel to further dissipate energy. The flat rock channel will also be repaired adding Class 150 as bedding material in addition to pea gravel. Additionally, Phase 2 improvements will direct flows away from this outfall to the proposed basin, reducing the amount of water that needs to be conveyed and erosion potential. The proposed improvements will not completely eliminate beach erosion at the Foothill location but will reduce it and direct it away from the pier.

3.4 LAKE CLARITY CREDITING

Table 4 details the results of the PLRM model used to calculate the relative FSP reduction for each alternative as compared to the existing conditions. Please note that the values for Total Phosphorus (TP), Total Nitrogen (TN), and FSP are the quantities remaining after treatment, not the quantities removed. The estimated PLRM credits achieved by this project are 20.

Table 3. PLRM Results

	Water Quality Parameter				
Scenario	**TP [lbs/yr]**	**TN [lbs/yr]**	**FSP [lbs/yr]**	**Ave. Annual Removal % FSP**	**Est. PLRM Credit**
Baseline/Existing Conditions	23	78	7215		
Zephyr Cove Water Quality Improvement Project	12	45	3242	55.1%	20

Assumptions/Notes:

1. *Did not take into account private party BMPs. They remained at 7/19/5 for SFR/MFR/CICU respectively throughout the modeling.*
2. *SFR/MFR/CICU % DCIA was estimated using PLRMv2.1 inputs and number of parcels discharging to the road vs. total number of parcels within sub-watersheds assuming each parcel is same size.*

4.0 PROJECT PERMITTING

The Project requires review by the USFS, TRPA, NDOT, and Douglas County.

4.1 USFS SPECIAL USE PERMIT AND NEPA CATEGORICAL EXEMPTION

Proposed work on a USFS parcel requires a Special Use Permit (SUP). The information presented in the SUP application since May 2014 has resulted in comments that have driven the designs.

For land outside of USFS property, NTCD prepared cultural and biological resource studies to meet the requirements of The National Environmental Policy Act (NEPA). These studies determined that the project was eligible for a Categorical Exclusion.

4.2 TRPA EIP PROJECT PERMIT

The Project will require a TRPA EIP Project Review Application and Initial Environmental Checklist. A permit was issued for the construction of Phase 1. A new permit will be necessary for Phase 2 and 100% plans will be submitted in February 2017.

4.3 STORMWATER POLLUTION PLAN PREVENTION (SWPPP)

The area of disturbance associated with the implementation of the Project is under an acre in size; therefore, a Stormwater Pollution Prevention Plan (SWPPP) is not necessary.

4.4 NDOT PERMIT

Due to construction within the NDOT right-of-way, the Project will require an NDOT encroachment permit. The application for this permit will be filed with 100% Phase 2 plans in February 2017 with assistance from NDOT staff.

4.5 DOUGLAS COUNTY PERMIT

Due to construction within the Douglas County right-of-way, the Project will require a Douglas County Site Improvement permit.

5.0 PROJECT MAINTENANCE

Assets will be maintained by both NDOT and ZCGID. Maintenance requirements were considered during design to make each asset maintainable using equipment currently owned by those responsible entities.

5.1 NDOT MAINTENANCE RESPONSIBILITIES

NDOT will maintain the installed conveyance along US Highway 50 as well as the installed infiltration basin. Drainage inlets will be cleaned at least annually using a vactor truck. The spacing of the weir from the drainage inlet side wall was set at a minimum of 10 inches so that the standard vactor hose could fit without removing the weir. The weir was designed to be removable in the event of necessary repair or replacement. Pipe maintenance or sediment buildup should not be an issue as slopes are much greater than the minimum 0.5 percent requirement.

The infiltration basin was designed to minimize drastic maintenance procedures like removing sediment from the basin itself. The drainage inlets conveying stormwater to the basin have considerable sump for coarse sediment to collect and will be maintained using a vactor truck at least annually. The infiltration basin has a built in access ramp in the event NDOT needs to remove sediment from the rock dissipator or bottom of the basin. Removal of this scale is expected every five years or less frequently.

5.2 ZCGID MAINTENANCE RESPONSIBILITIES

ZCGID will maintain both outfalls. Maintenance for both outfalls will include cleaning the existing infiltration vaults at least annually as they currently already do. For the Church Street Outfall, maintenance includes cleaning the rock lined ditch and rock bowl as needed as well as asphalt and curb replacement as needed. Both are expected to be infrequent. For the Foothill Outfall, the Xeripave pavers should be cleaned annually with pressure washing or mechanical vacuuming. Maintenance of the Foothill path also includes paver, curb, and asphalt replacement as needed and cleaning the rock lined ditch.

6.0 REFERENCES

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APPENDIX A: BASIN CALCULATIONS

Spreadsheet Illustrating Infiltration Basin Sizing
24 Hour Storms, NRCS Type 2 Rainfall Distribution

Church Basin: Alt 2

1 Hour Rainfall Depth =	0.58	in	Enter
Peak Rainfall Intensity =	10.61	in/hr	Calculated from distribution
Impervious Surface Square-Footage =	348936		Enter
Runoff Coefficient =	0.501		0.9 - 0.98 for imp surface
Basin Square-Footage =	4023		Enter
Ratio of Basin to Impervious Surface =	0.012		Calculated
Soil Infiltration Rate =	4	in/hr	Enter
Maximum Ponding Depth in Basin =	2.12	ft	
Depth of special media below Basin =	0.00	inches	
Void ratio for sub-basin soil =	20%	25% for eng soil, 40% for rock (1/8th roc	
Storage capacity of sub-basin soil=	0.00	cf	

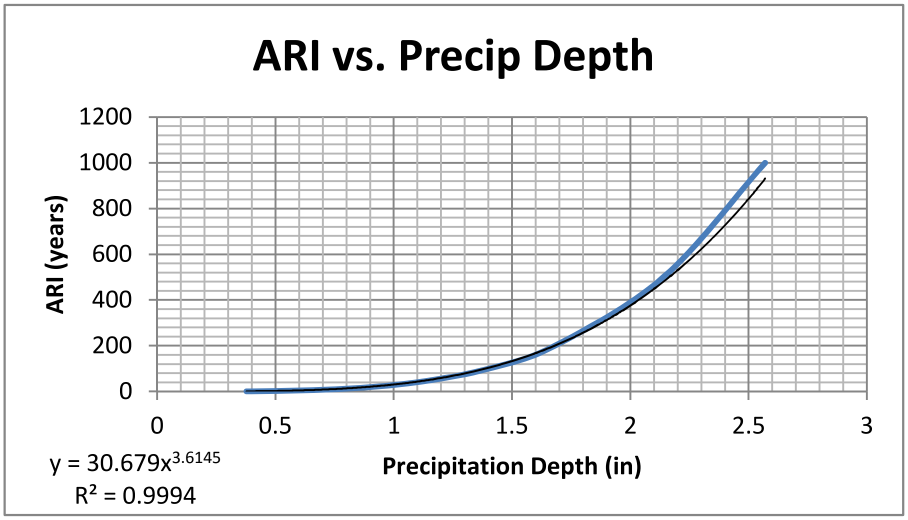
(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Maximum Infiltration Rate (cfs)	(8) Inflow - Infiltration Rate (cfs)	(9) Inflow - Infiltration Volume (cf)	(10) Cumulative Inflow - Outflow (cf)	(11) Rock trench Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0.3725	-0.37250	-9.3125	0.00	0.00
0.4167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7.59	0.00
0.8333	0.0006	0.08	0.34	8.44948	0.00029	0.3725	-0.03452	-0.8630	6.72	0.00
1.25	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	14.31	0.00
1.6667	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	21.90	0.00
2.0833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	29.48	0.00
2.5	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	37.07	0.00
2.9167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	44.66	0.00
3.3333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	52.24	0.00
3.75	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	59.83	0.00
4.1667	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	67.42	0.00
4.5833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	75.00	0.00
5	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	82.59	0.00
5.4167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	90.17	0.00
5.8333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	97.76	0.00
6.25	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	105.35	0.00
6.6667	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	112.93	0.00
7.0833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	120.52	0.00
7.5	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	128.11	0.00
7.9167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	135.69	0.00
8.3333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	143.28	0.00
8.75	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	150.87	0.00
9.1667	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	158.45	0.00
9.5833	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	174.49	0.00
10	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	182.07	0.00
10.417	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	198.11	0.00
10.833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	205.70	0.00
11.25	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	221.73	0.00
11.667	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	237.77	0.00
12.083	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	245.36	0.00
12.5	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	261.39	0.00
12.917	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	277.43	0.00
13.333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	285.01	0.00
13.75	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	301.05	0.00
14.167	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	317.09	0.00
14.583	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	324.67	0.00

15	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	340.71	0.00
15.417	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	356.74	0.00
15.833	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	381.23	0.00
16.25	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	397.27	0.00
16.667	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	413.30	0.00
17.083	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	437.79	0.00
17.5	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	453.82	0.00
17.917	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	469.86	0.00
18.333	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	494.34	0.00
18.75	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	510.38	0.00
19.167	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	526.42	0.00
19.583	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	550.90	0.00
20	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	566.94	0.00
20.417	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	591.42	0.00
20.833	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	624.36	0.00
21.25	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	648.84	0.00
21.667	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	681.78	0.00
22.083	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	706.26	0.00
22.5	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	739.20	0.00
22.917	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	772.13	0.00
23.333	0.0035	0.50	2.03	50.6969	0.00174	0.3725	1.65537	41.3844	813.52	0.00
23.75	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	846.45	0.00
24.167	0.0035	0.50	2.03	50.6969	0.00174	0.3725	1.65537	41.3844	887.84	0.00
24.583	0.0035	0.50	2.03	50.6969	0.00174	0.3725	1.65537	41.3844	929.22	0.00
25	0.0035	0.50	2.03	50.6969	0.00174	0.3725	1.65537	41.3844	970.61	0.00
25.417	0.0041	0.58	2.37	59.1463	0.00203	0.3725	1.99335	49.8338	1020.44	0.00
25.833	0.0046	0.67	2.70	67.5958	0.00232	0.3725	2.33133	58.2833	1078.72	0.00
26.25	0.0041	0.58	2.37	59.1463	0.00203	0.3725	1.99335	49.8338	1128.56	0.00
26.667	0.0064	0.92	3.72	92.9442	0.0032	0.3725	3.34527	83.6317	1212.19	0.00
27.083	0.0064	0.92	3.72	92.9442	0.0032	0.3725	3.34527	83.6317	1295.82	0.00
27.5	0.0064	0.92	3.72	92.9442	0.0032	0.3725	3.34527	83.6317	1379.45	0.00
27.917	0.0093	1.34	5.41	135.192	0.00465	0.3725	5.03516	125.8791	1505.33	0.00
28.333	0.0087	1.25	5.07	126.742	0.00436	0.3725	4.69719	117.4296	1622.76	0.00
28.75	0.0093	1.34	5.41	135.192	0.00465	0.3725	5.03516	125.8791	1748.64	0.00
29.167	0.0737	10.61	42.92	1073.08	0.0369	0.3725	42.55084	1063.7710	2812.41	0.00
29.583	0.0731	10.52	42.59	1064.63	0.03661	0.3725	42.21286	1055.3215	3867.73	0.00
30	0.0737	10.61	42.92	1073.08	0.0369	0.3725	42.55084	1063.7710	4931.50	0.00
30.417	0.0139	2.00	8.11	202.787	0.00697	0.3725	7.73900	193.4749	5124.98	0.00
30.833	0.0139	2.00	8.11	202.787	0.00697	0.3725	7.73900	193.4749	5318.45	0.00
31.25	0.0139	2.00	8.11	202.787	0.00697	0.3725	7.73900	193.4749	5511.93	0.00
31.667	0.0081	1.17	4.73	118.293	0.00407	0.3725	4.35921	108.9802	5620.91	0.00
32.083	0.0075	1.09	4.39	109.843	0.00378	0.3725	4.02123	100.5307	5721.44	0.00
32.5	0.0081	1.17	4.73	118.293	0.00407	0.3725	4.35921	108.9802	5830.42	0.00
32.917	0.0052	0.75	3.04	76.0453	0.00262	0.3725	2.66931	66.7328	5897.15	0.00
33.333	0.0058	0.84	3.38	84.4948	0.00291	0.3725	3.00729	75.1823	5972.33	0.00
33.75	0.0052	0.75	3.04	76.0453	0.00262	0.3725	2.66931	66.7328	6039.07	0.00
34.167	0.0041	0.58	2.37	59.1463	0.00203	0.3725	1.99335	49.8338	6088.90	0.00
34.583	0.0041	0.58	2.37	59.1463	0.00203	0.3725	1.99335	49.8338	6138.73	0.00
35	0.0041	0.58	2.37	59.1463	0.00203	0.3725	1.99335	49.8338	6188.57	0.00
35.417	0.0035	0.50	2.03	50.6969	0.00174	0.3725	1.65537	41.3844	6229.95	0.00
35.833	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	6262.89	0.00
36.25	0.0035	0.50	2.03	50.6969	0.00174	0.3725	1.65537	41.3844	6304.27	0.00
36.667	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	6337.21	0.00
37.083	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6361.69	0.00
37.5	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	6394.63	0.00
37.917	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6419.11	0.00

38.333	0.0029	0.42	1.69	42.2474	0.00145	0.3725	1.31740	32.9349	6452.05	0.00
38.75	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6476.53	0.00
39.167	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6501.02	0.00
39.583	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6525.50	0.00
40	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6549.99	0.00
40.417	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6574.47	0.00
40.833	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6598.96	0.00
41.25	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6623.44	0.00
41.667	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6639.48	0.00
42.083	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6663.97	0.00
42.5	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6680.00	0.00
42.917	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6696.04	0.00
43.333	0.0023	0.33	1.35	33.7979	0.00116	0.3725	0.97942	24.4854	6720.52	0.00
43.75	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6736.56	0.00
44.167	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6752.60	0.00
44.583	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6768.63	0.00
45	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6784.67	0.00
45.417	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6800.70	0.00
45.833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6808.29	0.00
46.25	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6824.33	0.00
46.667	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6840.36	0.00
47.083	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6847.95	0.00
47.5	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6863.98	0.00
47.917	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6880.02	0.00
48.333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6887.61	0.00
48.75	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6903.64	0.00
49.167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6911.23	0.00
49.583	0.0017	0.25	1.01	25.3484	0.00087	0.3725	0.64144	16.0359	6927.26	0.00
50	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6934.85	0.00
50.417	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6942.44	0.00
50.833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6950.02	0.00
51.25	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6957.61	0.00
51.667	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6965.20	0.00
52.083	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6972.78	0.00
52.5	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6980.37	0.00
52.917	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6987.96	0.00
53.333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	6995.54	0.00
53.75	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7003.13	0.00
54.167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7010.72	0.00
54.583	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7018.30	0.00
55	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7025.89	0.00
55.417	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7033.47	0.00
55.833	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7041.06	0.00
56.25	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7048.65	0.00
56.667	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7056.23	0.00
57.083	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7063.82	0.00
57.5	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7071.41	0.00
57.917	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7078.99	0.00
58.333	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7086.58	0.00
58.75	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7094.17	0.00
59.167	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7101.75	0.00
59.583	0.0006	0.08	0.34	8.44948	0.00029	0.3725	-0.03452	-0.8630	7100.89	0.00
60	0.0012	0.17	0.68	16.899	0.00058	0.3725	0.30346	7.5865	7108.48	0.00
60.417	0.0000	0.00	0.00	0	0	0.3725	-0.37250	-9.3125	7099.16	0.00
60.833	0.0000	0.00	0.00	0	0	0.3725	-0.37250	-9.3125	7089.85	0.00
	0.58			0	**0.29**					

From NOAA

ARI* (years)	60 min
1	0.377
2	0.468
5	0.609
10	0.745
25	0.963
50	1.16
100	1.4
200	1.68
500	2.14
1000	2.57



1 hr storm depth (in)	ARI		
0.58	4	~5 year	Alt 2
1.18	56	~ 50 year	Alt 1

vol	8500	cu ft
depth	2.112851	ft

Alt 2	0.58	inches/hr	1 hr, 5 year storm
Capacity	8500	cu ft	
Capacity	0.20	acre ft	

APPENDIX B: CONVEYANCE AND SPREAD CALCULATIONS

Conveyance Calculations for Zephyr Cove WQIP

MANNINGS ROUGHNESS ASSUMPTIONS

n assumptions	n	
Snaptite HDPE	0.00914	from http://www.culvert-rehab.com/pdfs/2013_manual.pdf
ACB	0.02	
CMP	0.024	
RCP	0.013	

assume V min = 3ft/sec, max = 20 ft/s per TMRDM (slope min = 0.25 %) (min cover 1.5 for RCP, 2.5 for all other) (12" min diameter)
Vmax for pipes = 15 ft/s according to Douglas County Standard

Flow from Catchments	**Peak Q (cfs)**	**Peak Q (cfs)**	
	100 year (Max)	**25 year (Design)**	
ZC07 (upper NDOT catchment, need to connect)	3.7	2.6	3.7 cfs is the 100 yr Peak Q to convey at 1st section of pipe
ZC05 (already connected NDOT catchment)	2.6	1.5	6.3 cfs is the 100 year peak Q to convey at the 2nd section of pipe
ZC06 (NDOT catchment to flows to south of 50)	0.9	0.3	

Proposed Pipe

US HWY 50 Straight Section

CIRCULAR MANNINGS CALCULATOR FOR NON-PRESSURE FLOW

input	value	units
depth of water (y)	0.7	ft
diameter (I.D. of 14" snaptite)	13.09	inches
diameter	1.090833333	ft
radius	0.545416667	
cross sectional area (A_c)	0.633618539	ft2
wetted perimeter (P)	2.026939988	ft
channel slope (S)	0.0064	ft/ft
hydraulic radius (R)	0.312598568	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.00914	
mean velocity (v)	5.990833604	ft/s
flow (Q)	**3.80**	**cfs**

volume exceeds 100 year flow of 3.7 cfs at 60% full

Check using full pipe eqn: Q = 0.0006138 x (d^8/3 x S^0.5)/n where d is in inches

flow (Q)	**5.11**	**cfs**

14" Snaptite ok because at full flow exceeds 100 year flow of 3.7 cfs

US Hwy 50 Curved Section

CIRCULAR MANNINGS CALCULATOR FOR NON-PRESSURE FLOW

input	value	units
depth of water (y)	0.545	ft
dia (I.D of 14" snaptite)	13.09	inches
diameter	1.090833333	ft
radius	0.545416667	
cross sectional area (A_c)	0.466824941	ft2
wetted perimeter (P)	1.71264366	ft
channel slope (S)	0.0502	ft/ft
hydraulic radius (R)	0.27257564	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.00914	
mean velocity (v)	15.31378336	ft/s
flow (Q)	**7.15**	**cfs**

volume exceeds 100 year flow of 6.3 cfs at half full

Check using full pipe eqn: Q = 0.0006138 x (d^8/3 x S^0.5)/n where d is in inches

flow (Q)	**14.32**	**cfs**

14" Snaptite ok

Proposed Pipe (cont'd from previous page)

US HWY 50 Straight Section				**US Hwy 50 Curved Section**			
Min Velocity of 3ft/sec at design flow (Q peak 25 year for Hwy 50)							
depth of water (y)	0.552	ft		depth of water (y)	0.4	ft	
cross sectional area (A_c)	0.4744606	ft2		cross sectional area (A_c)	0.310553959	ft2	
wetted perimeter (P)	1.72664398	ft		wetted perimeter (P)	1.419082944	ft	
hydraulic radius (R)	0.274787742	ft		hydraulic radius (R)	0.218841302	ft	
mean velocity (v)	5.497444295	ft/s		mean velocity (v)	13.22850194	ft/s	
flow (Q)	**2.61**	**cfs (= to 25 yr flow of 2.6 cfs)**		flow (Q)	**4.11**	**cfs (= to 25 yr flow of 4.1 cfs)**	
velocity above 3ft/sec at design flow so OK				**velocity above 3ft/sec at design flow so OK**			
EGL/HGL - pipe does not flow full so open channel governs, HGL is water surface							
EGL = V^2/2g	**25 year**	**100 year**		**EGL = V^2/2g**	**25 year**	**100 year**	
EGL in feet above water surface	0.47	0.56			2.72	3.64	
HGL is never above road surface, so ok							

Conveyance Calculations for Zephyr Cove WQIP

Existing ACB Channel

Trapezoid MANNINGS CALCULATOR

input	value	units	
trapezoidal side slope (s)	1	unitless	
depth of water (y)	0.5	ft	
base of trapezoid	2	ft	
cross sectional area (A_c)	1.25	ft2	
wetted perimeter (P)	4	ft	
channel slope (S)	0.035	ft/ft	conservative
hydraulic radius (R)	0.3125	ft	
conversion (C_1)	1.486		
Mannings roughness (n)	0.02		
mean velocity (v)	6.40	ft/s	
channel flow (Q)	8.00	cfs	

With 6" of water, it passes well over 100 year flow of 5.2 cfs for Alt 2, and 7.2 as existing conditions

Existing ACB Channel OK

Existing RCP Pipe

CIRCULAR MANNINGS CALCULATOR

input	value	units	
depth of water (y)	1	ft	
diameter	24	inches	
diameter	2	ft	
radius	1		
cross sectional area (A_c)	1.570796327	ft2	
wetted perimeter (P)	3.141592654	ft	
channel slope (S)	0.01	ft/ft	conservative assumption
hydraulic radius (R)	0.5	ft	
conversion (C_1)	1.486		
Mannings roughness (n)	0.013		
mean velocity (v)	7.20	ft/s	
flow (Q)	**11.31**	**cfs**	

volume exceeds 100 year flow of 6.3cfs at half full

Check using full pipe eqn: Q = 0.0006138 x (d^8/3 x S^0.5)/n where d is in inches

flow (Q)	**22.62**	**cfs**

24" pipe can accept new flow

Since all pipes are flowing less than 1/2 full, channel and not orifice flow is assumed. Also, surcharge is not an issue.

Conveyance Calculations for Zephyr Cove WQIP

DI Weir Design

US HWY 50 Straight Section

25 year storm is 2.6 cfs. 2 year storm is 0.9 cfs. Goal is to send 5-10 year storm

input	value	units
depth of water (in)	3.25	inches
depth of water (y)	0.270833333	ft
diameter (I.D. of 14" snaptite)	13.09	inches
diameter	1.090833333	ft
radius	0.545416667	
cross sectional area (A_c)	0.180938047	ft2
wetted perimeter (P)	1.137982884	ft
channel slope (S)	0.0151	ft/ft
hydraulic radius (R)	0.158998918	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.00914	
mean velocity (v)	5.863503651	ft/s
flow (Q)	**1.06**	**cfs**

Existing outlet activates when new outlet is flowing 3.25 inches full.

US Hwy 50 Curved Section

25 year storm is 2.6 cfs (sum of sub-catchments 5 and 6), 2 year is 1.1 cfs

input	value	units
depth of water (in)	3.75	inches
depth of water (y)	0.3125	ft
diameter (I.D. of 14" snaptite	13.09	inches
diameter	1.090833333	ft
radius	0.545416667	
cross sectional area (A_c)	0.221154955	ft2
wetted perimeter (P)	1.232178786	ft
channel slope (S)	0.0502	ft/ft
hydraulic radius (R)	0.179482846	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.00914	
mean velocity (v)	11.59061383	ft/s
flow (Q)	**2.56**	**cfs**
new flow (from ZC 06)	**1.50**	cfs

new flow takes out the flow entering the DI from the straight pipe section

Basin Manhole Weir Design

Calculating height above basin invert to put outlet pipe

input	value	units
depth of water (in)	4.25	inches
depth of water (y)	0.354166667	ft
diameter	18	inches
diameter	1.5	ft
radius	0.75	
cross sectional area (A_c)	0.318672546	ft2
wetted perimeter (P)	1.522221261	ft
channel slope (S)	0.0151	ft/ft
hydraulic radius (R)	0.20934706	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.00914	
mean velocity (v)	7.043778082	ft/s
flow (Q)	**2.24**	**cfs**

Bypass activates when inlet pipe is flowing 4.25 inches full

General 18" CMP capacity calculation (basin overflow and bypass pipe)

input	value	units
depth of water (in)	9	inches
depth of water (y)	0.75	ft
diameter	18	inches
diameter	1.5	ft
radius	0.75	
cross sectional area (A_c)	0.883572934	ft2
wetted perimeter (P)	2.35619449	ft
channel slope (S)	0.005	ft/ft
hydraulic radius (R)	0.375	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.024	
mean velocity (v)	2.276739881	ft/s
flow (Q)	**2.01**	**cfs**

half full pipe is near 100 year overflow of 2.2 cfs

Check using full pipe eqn: Q = 0.0006138 x (d^8/3 x S^0.5)/n where d is in inches

flow (Q)	**4.02**	cfs

C&G Spread

Question: How far does the 25 year storm spread from existing C&G, asphalt dike, or wall into the Highway? These conditions are existing and will not be changed by the project.

Assumptions: The Highway 50 cross slope is assumed to be 2%, 5% on shoulders where grates are present without concrete gutters, cross slope of proposed curb is used as Sx; road assumed crowned in ZC07 and 06, super elevated in ZC05 for Rational Method calculations

road assumed crowned in ZC07 and 06, super elevated in ZC05 for Rational Method calculations

Design ZC07	**value**		**notes**
	25 yr	**100 yr**	
Q [cfs]	0.30	0.45	
longitudinal slope, Sl	2.59%	2.59%	from CAD
cross slope, Sx	8.33%	8.33%	from Type 1 detail 2" over 2'
Manning's, n	0.015	0.015	per NDOT, 2006
cub and gutter spread, T	**1.53**	**1.79**	equation 4-2 from HEC 22
T= [Q_{25}*n/(K*Sx^1.67*Sl^0.5)]^0.375			
Allowable spread = gutter width only [ft]	<= 2.0	<= 2.0	OKAY!
check depth [ft]	0.13	0.15	d= T*Sx, <= 0.5

Design ZC05	**value**		**notes**
	25 yr	**100 yr**	
Q [cfs]	0.22	0.33	
longitudinal slope, Sl	2.92%	2.92%	from CAD
cross slope, Sx	5.00%	5.00%	field estimate
Manning's, n	0.015	0.015	per NDOT, 2006
cub and gutter spread, T	**1.84**	**2.14**	equation 4-2 from HEC 22
T= [Q_{25}*n/(K*Sx^1.67*Sl^0.5)]^0.375			
Allowable spread = gutter width only [ft]	<= 1.8	>= 1.8	OKAY!, travels minimally outside the FOG line in the 100 year event
check depth [ft]	0.09	0.11	d= T*Sx, <= 0.5

Design ZC06	**value**		**notes**
	25 yr	**100 yr**	
Q[cfs]	0.08	0.12	There is no topo connection between ZC07 and ZC06
longitudinal slope, Sl	3.02%	3.02%	from CAD surface
cross slope, Sx	5.00%	5.00%	field estimate
Manning's, n	0.015	0.015	per NDOT, 2006
cub and gutter spread, T	**1.27**	**1.48**	equation 4-2 from HEC 22
T= [Q_{25}*n/(K*Sx^1.67*Sl^0.5)]^0.375			
Allowable spread = gutter width only [ft]	<= 2.0	<= 2.0	OKAY!
check depth [ft]	0.06	0.07	d= T*Sx, <= 0.25

DI Grate Size

Assumptions: Use 2' wide grate, no side flow interception because spread is contained within 2' wide grate width. Q25 design storm assume weir flow

Design Up gradient Grate	value		notes
	25 yr	100 yr	
Q = C*P*d^1.5, where...			equation 4-26 from HEC-22
Q= Flow to proposed inlet in cfs	0.30	0.45	
C = 3.0 for English units	3.0	3.0	
d= average depth across grate = T*Sx	0.13	0.15	
P = Perimeter of grate (disregarding the curb side of grate)			
P = Q/(C*(T*Sx)^1.5)	2.16	2.59	
Assume 50% clogging factor for inlet in sump	3.25	3.88	current 2'x4' grate (P=8') is adequate

Design Middle Grate	value		notes
	25 yr	100 yr	
Q = C*P*d^1.5, where...			equation 4-26 from HEC-22
Q= Flow to proposed inlet in cfs	#REF!	#REF!	
C = 3.0 for English units	3.0	3.0	
d= average depth across grate = T*Sx	#REF!	#REF!	
P = Perimeter of grate (disregarding the curb side of grate)			
P = Q/(C*(T*Sx)^1.5)	#REF!	#REF!	current 2'x4' grate (P=8') is adequate, not considering trench drain

Design Down gradient Grate	value		notes
	25 yr	100 yr	
Q = C*P*d^1.5, where...			equation 4-26 from HEC-22
Q= Flow to proposed inlet in cfs	0.22	0.33	assume middle grate takes 100% of upstream flow
C = 3.0 for English units	3.0	3.0	
d= average depth across grate = T*Sx	0.09	0.11	
P = Perimeter of grate (disregarding the curb side of grate)			
P = Q/(C*(T*Sx)^1.5)	2.60	3.11	current 2'x4' grate (P=8') is adequate no trench necessary

APPENDIX C: OUTFALL CALCULATIONS

Zephyr Cove WQIP Outfall Calculations

MANNINGS ROUGHNESS ASSUMPTIONS

n assumptions	Min	Norm	Max	
ACB	0.017	0.02	0.028	(max assumes mature grass)
Grass	0.03	0.04	0.05	
Rock	0.035			
Concrete	0.011	0.013	0.015	
HDPE		0.01		
Asphalt	0.013		0.016	(max is rough surface, use for xeripave)
Xeripave		0.016		estimated from rough asphalt

assume V min = 3ft/sec, max = 20 ft/s per TMRDM (slope min = 0.25 %) (min cover 1.5 for RCP, 2.5 for all other) (12" min diameter)
Vmax for pipes = 15 ft/s according to Douglas County Standard

Outfall Flows	**Alt 1**	**Alt 1**	**Alt 2**	**Alt 2**
	Qave, 25 yr (cfs)	**Q ave, 100 yr (cfs)**	**Qave, 25 yr (cfs)**	**Q ave, 100 yr (cfs)**
Church Street	1.5	1.9	4.6	5.2
Foothill	3.2	4.8	0.6	2.3

Proposed Pipe

CHURCH

CIRCULAR MANNINGS CALCULATOR

input	value	units	
depth of water (y)	0.525	ft	
DIA	1.5	ft	
R	0.75		
cross sectional area (A_c)	0.551206076	ft2	
wetted perimeter (P)	1.899155509	ft	
channel slope (S)	0.075	ft/ft	
hydraulic radius (R)	0.290237462	ft	
conversion (C_1)	1.486		
Mannings roughness (n)	0.013		
mean velocity (v)	13.72	ft/s	
channel flow (Q)	7.56	cfs	
length of flow	146		
Froude number = v/(sqrt(g)*L)	0.200141601	subcritical	
scour time	28	min	assume for 1A
Scour, sigma	1.87	sand	
Scour, alpha	2.27	for depth	
C(h)	1	no drop	
C(s)	1.12	slope >7%	
h(s)	0.424992193	ft	
D50	1	ft	
ye	0.524979083		
C0 (tailwater parameter)	1.4	assumes TW/ye<0.75	

FOOTHILL

CIRCULAR MANNINGS CALCULATOR

input	value	units
depth of water (y)	0.26	ft
DIA	1.5	ft
R	0.75	
cross sectional area (A_c)	0.204861352	ft2
wetted perimeter (P)	1.288225908	ft
channel slope (S)	0.12	ft/ft
hydraulic radius (R)	0.159025952	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.013	
mean velocity (v)	11.62	ft/s
channel flow (Q)	2.38	cfs
length of flow	167	
Froude number	0.158498533	subcritical
scour time	28	min
Scour, sigma	1.87	sand
Scour, alpha	2.27	depth
C(h)	1	no drop
C(s)	1.12	slope >7%
h(s)	0.266731893	ft

ok, but pipe not feasible due to horizontal separation required

scour calculation source, hec14

Zephyr Cove WQIP Outfall Calculations

hs (dissipator pool depth (ft)	0.322239496		
Ls = 10*hs	3.222394964	ft	
Ls(min) = 3*Wo	4.5	ft	choose this
LB = 15*hs	4.833592446		
LB(min) = 4*Wo	6	ft	choose this
WB = Wo+2(Lb/3)	5.5	ft	

Articulated Concrete Block Path

CHURCH

Rectangular Mannings Calculator

input	value	units	
depth of water (y)	0.12	ft	
width of rectangle	9	ft	
cross sectional area (A_c)	1.08	ft2	
wetted perimeter (P)	9.24	ft	
channel slope (S)	0.078	ft/ft	
hydraulic radius (R)	0.116883117	ft	
conversion (C_1)	1.486		
Mannings roughness (n)	0.02		
mean velocity (v)	4.96	ft/s	
channel flow (Q)	5.36		
length of flow	146		
Froude number	0.072349068	subcritical	
scour time	15	min	assume for 1A
Scour, sigma	1.87	sand	
Scour, alpha	2.27	depth	
C(h)	1	no drop	
C(s)	1.12	slope >7%	
h(s)	0.349801754	ft	

FOOTHILL

Rectangular Mannings Calculator

input	value	units
depth of water (y)	0.076	ft
width of rectangle	14	ft
cross sectional area (A_c)	1.064	ft2
wetted perimeter (P)	14.152	ft
channel slope (S)	0.12	ft/ft
hydraulic radius (R)	0.07518372	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.02	
mean velocity (v)	4.58	ft/s
channel flow (Q)	4.88	
length of flow	167	
Froude number	0.062523383	subcritical
scour time	15	min
Scour, sigma	1.87	sand
Scour, alpha	2.27	depth
C(h)	1	no drop
C(s)	1.12	slope >7%
h(s)	0.333550714	ft

Asphalt Path

CHURCH

Rectangular Mannings Calculator

input	value	units
depth of water (y)	0.09	ft
width of rectangle	9	ft
cross sectional area (A_c)	0.817140912	ft2
wetted perimeter (P)	9.181586869	ft
channel slope (S)	0.078	ft/ft
hydraulic radius (R)	0.088997787	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.013	
mean velocity (v)	6.36	ft/s
channel flow (Q)	5.20	
length of flow	146	
Froude number	0.092812086	subcritical

FOOTHILL

Rectangular Mannings Calculator

input	value	units
depth of water (y)	0.06	ft
width of rectangle	14	ft
cross sectional area (A_c)	0.812898504	ft2
wetted perimeter (P)	14.11612836	ft
channel slope (S)	0.12	ft/ft
hydraulic radius (R)	0.057586506	ft
conversion (C_1)	1.486	
Mannings roughness (n)	0.013	
mean velocity (v)	5.90	ft/s
channel flow (Q)	4.80	
length of flow	167	
Froude number	0.080524319	subcritical

scour time	15	min	assume for 1A	scour time	15	min
Scour, sigma	1.87	sand		Scour, sigma	1.87	sand
Scour, alpha	2.27	depth		Scour, alpha	2.27	depth
C(h)	1	no drop		C(h)	1	no drop
C(s)	1.12	slope >7%		C(s)	1.12	slope >7%
h(s)	0.343407785	ft		h(s)	0.329252225	ft

Asphalt Path with Xeripave strips

CHURCH				**FOOTHILL**		
Rectangular Mannings Calculator				Rectangular Mannings Calculator		
input	value	units		input	value	units
depth of water (y)	0.1	ft		depth of water (y)	0.07	ft
width of rectangle	9	ft		width of rectangle	14	ft
cross sectional area (A_c)	0.9	ft2		cross sectional area (A_c)	0.98	ft2
wetted perimeter (P)	9.2	ft		wetted perimeter (P)	14.14	ft
channel slope (S)	0.078	ft/ft		channel slope (S)	0.12	ft/ft
hydraulic radius (R)	0.097826087	ft		hydraulic radius (R)	0.069306931	ft
conversion (C_1)	1.486			conversion (C_1)	1.486	
Mannings roughness (n)	0.016			Mannings roughness (n)	0.016	
mean velocity (v)	5.51	ft/s		mean velocity (v)	5.43	ft/s
channel flow (Q)	4.96			channel flow (Q)	5.32	
length of flow	146			length of flow	167	
Froude number	0.080317753	subcritical		Froude number	0.074026586	subcritical
scour time	15	min	assume for 1A	scour time	15	min
Scour, sigma	1.87	sand		Scour, sigma	1.87	sand
Scour, alpha	2.27	depth		Scour, alpha	2.27	depth
C(h)	1	no drop		C(h)	1	no drop
C(s)	1.12	slope >7%		C(s)	1.12	slope >7%
h(s)	0.337836467	ft		h(s)	0.344313284	ft

APPENDIX D: RESPONSES TO 75 AND 90 PERCENT COMMENTS

Comments on Zephyr Cove GID Water Quality Improvement Project						
			Commenter: Erik Nilssen P.E., Douglas County	**Responder: NTCD Engineering**	**Commenter: Erik Nilssen P.E.& Courtney Walker, Douglas County**	**Responder: NTCD Engineering**
Comment #	Document	Sheet	75% Comment	75% Response	90% Comment	90% Response
DC-1	Plans	1	Label major roadways on the location map	Added	No roadway names were added on the location map(called "Plan").	Names added to 100% phase 1(P1) plan.
DC-2	Plans	3	All streets should be labeled. All parcels should have an address or APN shown	Will add APNs for 100%	Okay, will look for APN on the 100% plans. Add street names as well.	APNs added to sheet C-1.
DC-3	Plans	6	The construction centerline on this sheet does not appear to have any horizontal control. It's just a line through the turf stone. The line should have beari ngs at all changes in alignment.	Horizontal control will be set during staking.	Horizontal control needs to be shown on the plan set. Needs to be a start and stop location for the construction centerline. Someone must be able to take the plane set you have and be able to locate the centerline in the future for locating and potholing utilities.	More horizontal information was given including a line/curve table for both alignments and additional stationing for improvements. As-builds will be provided to aid in future location of any underground improvements.
DC-4	Plans	6	"Remove and Replace Wood Decking and Stairs" should have a detail	Requiring an in kind replacement	Plan should state "replace in kind"	Language has been added to 100% plans.
DC-5	Plans	6	Should provide elevations every 50' or 100' along the edges of the turfstone.	Will be provided during staking	elevations need to be provided during design	Additional elevations were included in the 100% P1 plans.
DC-6	Plans	6	On the south side, it looks like a fence will need to be removed for the insta llation of the turfstone. Please callout removal, or if it is going to remain call out to protect in place.	Protect in Place called out	I do not see this note added to the plans, but it should be. The fence in question runs along the bottom of the plan view (south side of project).	Call out has been added to 100% P1 plans.
DC-7	Plans	6	What are the dashed lines that run north/south (STA 30 and STA 75), please label	Parcel boundaries, will add to 100%	Ok, will look forward to 100%	Call out for parcel boundary has been added to this sheet in addition to identification in the legend on the notes sheet.
DC-8	Plans	6	Is there any demo and removal of existing asphalt? This will be a pay item and should be stated on the plans	Added to plans	I did not see where this was added.	The call out for re-pavement states: "demo existing pavement and repave…." AC paving and Remove Existing Improvements are included as bid items and described in Special Provisions
DC-9	Plans	6	Add rim and invert elevations of the existing catch basin on the west side of the turfstone.	Will add at 100%	Ok, will look forward to 100%	Rim elevation and approximate vault depth added to 100% P1 plans.
DC-10	Plans	6	Need sanitary sewer and electric on the profile	Will add at 100%	Ok, will look forward to 100%	Sanitary sewer and electrical utility depth are unknown. Conflicts are not anticipated as improvements are surface or near surface. Contract will be responsible for potholing as necessary and protecting utilities in place as notes on the plans and described in the Special Provisions.
DC-11	Plans	6	Add the STA where the turfstone ends and concrete channel begins on the profile.	Will add at 100%	Ok, will look forward to 100%	Station added to beginning of flat rock channel for the 100% P1 plan.
DC-12	Plans	7	Need STA limits in the profile for rock bowl start and end and flat top rock channel.	Will add at 100%	Ok, will look forward to 100%	Additional stationing was added to the plan view for the 100% P1 plans.
DC-13	Plans	7	Need rim and invert elevations of catch basins and manholes on the plan sheet	Will add at 100%	Ok, will look forward to 100%	Catch basin rim and invert elevations have been added to 100% P1 plan.
DC-14	Plans	7	Need elevations every 50' or 100' for new pavement installation.	Will be provided during staking	Needs to be provided on the plans.	Additional elevations were included in the 100% P1 plans.
DC-15	Plans	10	Detail 3 - 6" of AC is extremely thick. We only use 4-inches generally on our arterial streets.	Modified to 3" for everywhere but NDOT ROW	Detail shows 6" of AC	Detail has been revised to 3" for 100% P1 plan.
DC-16	Plans	10	If turfstone is a proprietary product, you must call out "or approved equal" if this is going out for public bid. It would be good to list more than one product on the plans.	Noted, will be added to 100% plans for Xeripave and Snaptite	Ok, will look forward to 100%	"or equivalent" has been included in xeripave call out.
DC-17	90% Plans	4			Wondering on Snaptite HDPE, the profile calls out "Begin 14" Snaptite HDPE" and "End 15-inch Snaptite HDPE." I am not familiar with Snaptite HDPE, but I assume it's the same diameter all the way through the profile?	Call outs have been corrected to 14" HDPE throughout for 100% phase 2 (P2) plans.
DC-18	90% Plans	6			Note 3 states Typical Turfstone Section." Should be revised to Xeripave Strip"	Note has been revised for 100% P1 plan.
DC-19	Design Report				My main comment is in relation to section 3.4 of the Design Report. The estimated credits anticipated for this project (20) was determined using PLRM V1. The baseline has been revised using V2, so the number of credits will likely change. Are there plans to remodel using V2?	Note 2 of Table 3 in the 90% design report contains a typo. PLRM was run on August 12, 2015 using PLRM v2.1 with the updated GIS shapefiles. Since it was run using PLRM v2.1, the baseline loads will likely not change, so the estimated credits anticipated from this project (20) will likely not change significantly. Once we finalize the design , NTCD will re-run both the baseline and expected conditions scenarios, with double-checking the GIS layers, to determine the final credits achieved for this project.

Comments on Zephyr Cove GID Water Quality Improvement Project				
			Commenter: Ed Skudlarek	**Responder: NTCD Engineering**
Comment #	Document	Page	Comment	Response
NDEP-1	75% Design Basis Memo	2	*various edits to infiltration vs. retention sentence*	Noted
NDEP-2	75% Design Basis Memo	2	18 trees are X-ed on the 75% plan sheet C-3. Is it feasible to carefully grade around the three trees (30", 32" JP, 12"?) in the north lobe of the basin in order to keep them? If extra funds become available, can a portion of the bottom be designed as if it were a rain garden, with engineered soil and native shrub plantings? Cost estimate of March 16, 2016 counts 14 trees, an error.	16 trees are slated for removal. 3 additional X's are shown for stumps. We examined grading around trees, but it reduces basin capacity which we need.
NDEP-3	75% Design Basis Memo	2	The description here of the special needs of the conveyance system, drop inlets with weirs, and flow splitter indicates a need for special inspection and maintenance practices and schedule. To help ensure appropriate O&M, the mentioned stormwater system factors should be explained in project design report and included in BMP registration as appropriate for load reduction credit. Will sediment accumulate relatively rapidly in the pipe section sloped 0.5%? Is potential for constricted flow path small, moderate, high? Will sump be required and located for ease of access for sediment evacuation? Examine proper size of opening in grate of trench drain and other inlet types to prevent larger litter/trash items getting into and constricting flow in the conveyances and inlets.	Please see the maintenance section of the design report for maintenance discussions. Pipe slope is steeper than 0.5% A trench drain was eliminated from the project. Calculations show adequate velocity to flush pipes.
NDEP-4	75% Design Basis Memo	3	The vaults have not been categorized as infiltration features in previous project materials. Will the infiltration capacity be represented in PLRM to calculate load [reduction, explain what features about the vaults gives it infiltration BMP properties?	The vaults will still not be considered infiltration features due to their tendency to clog.
NDEP-5	75% Design Basis Memo	3	Weep holes existing, or to be drilled?	To be drilled.
NDEP-6	75% Design Basis Memo	4	The funding set aside for each outfall is $40,000, total $80,000, relatively high cost item. Next highest expense category is $20,000 for removal of 14 trees (actually 18 trees are X-ed out on plan set), and perhaps three trees can be retained in the northern lobe of the proposed basin, reducing total tree removal cost. Is it essential to extend the Turfstone and flat bottom rock channel all the way to the backshore line? Less development in the beach area means less maintenance of structure. As proposed, the amount of outfall construction in the beach area detracts from the beach and increases risk of wave damage.	We examined over outfall options and expect to revise this cost.

Comments on Zephyr Cove GID Water Quality Improvement Project				
			Commenter: Erik Nilssen P.E., Douglas County	**Responder: NTCD Engineering**
Comment #	Document	Sheet	Comment	Response
DC-18	75% Plans	6	Need sanitary sewer and electric on the profile	Will add at 100%
DC-19	75% Plans	6	Add the STA where the turfstone ends and concrete channel begins on the profile.	Will add at 100%
DC-20	75% Plans	6	Add detail for the modification of the existing catchbasin.	Added
DC-21	75% Plans	7	Note - "re-pave path to existing extents ...". Need a detai l on th is. Are you overlaying the existing pavement? Removing and replacing the existing pavement?	Removing. Added in detail.
DC-22	75% Plans	7	Need STA limits in the profile for rock bowl start and end and flat top rock channel.	Will add at 100%
DC-23	75% Plans	7	Need rim and invert elevations of catch basins and manholes on the plan sheet	Will add at 100%
DC-24	75% Plans	7	Need elevations every 50' or 100' for new pavement installation.	Will be provided during staking
DC-25	75% Plans	10	Detail 3 - 6" of AC is extremely thick. We only use 4-inches generally on our arterial streets.	Modified to 3" for everywhere but NDOT ROW
DC-26	75% Plans	10	Detail 4 - The cross slope on the turfstone path is shown as 4% on the detail and 2% on the plan sheets.	2% is the correct slope
DC-27	75% Plans	10	If turfstone is a proprietary product, you must call out "or approved equal" if this is going out for public bid. It would be good to list more than one product on the plans.	Noted, will be added to 100% plans for Xeripave and Snaptite
DC-28	75% Plans	10	Confused about the "as required" for the mirafi geotextile fabric. When do you anticipate it will be required? Should be an "allowance" on the bid schedule if you are not sure it will be used.	Will not be using mirafi fabric as clogging is likely. Switched to pea gravel.

Comments on Zephyr Cove GID Water Quality Improvement Project				
			Commenter: Gary Richert, ZCGID	**Responder: NTCD Engineering**
Comment #	Document	Page	Comment	Response
GID-1	General		DI at corner of foothill clogs at surface frequently – perhaps a double combination DI is necessary	This DI is currently not being modified at all. Adding it is outside of the project survey. NTCD will monitor it and consider a future project.
GID-2	General		Add another infiltration vault at both foothill and church	An additional infiltration vault does not provided much treatment for the additional cost - especially of fine sediment.
GID-3	General		Okay to excavate at foothill as he saw that sewer main put in and it is off to the side.	Noted. Steepness makes it hard to keep velocities limited with a pipe so xeripave chosen.

APPENDIX E: GEOTECHNICAL MEMORANDUM

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November 7, 2016
Job No.: 1669.001

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P.O. Box 915
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mgrammenos@ntcd.org

Subject: Laboratory Testing and Recommendations
Zephyr Cove Stormwater Quality Basin
Zephyr Cove, Douglas County, Nevada

Dear Ms Grammenos:

Marvin E. Davis & Associates (MDA) is pleased to present results of laboratory testing and recommendations for stormwater quality basin (WQB) design by North Tahoe Conservation District (NTCD) for a proposed new WQB at the corner of Church Street and U.S. Highway 50 in Zephyr Cove, Nevada.

PROJECT DESCRIPTION

The proposed basin is at the northwest corner of US Highway 50 and Church Street. The site is presently wooded and surrounded by a wooden/rope fence. The site is gently sloped at approximately 4% grade between Elevation 6,265 and 6,268 feet. The proposed water quality basin would have a uniform bottom elevation of 6,265 feet and a top of berm at 6,269 feet. Between 0 and 4 feet of soil would be cut from existing grade in the bottom of the basin. This soil is proposed to be reused as fill for constructing the berms. The maximum height of the berm would be approximately 4 feet on the downhill side. The proposed maximum fill elevation is 6,268 feet, assuming that water fills no higher than 6 inches above the emergency outlet.

REFERENCES

The following information was provided to MDA in the course of this assessment:

- Nevada Tahoe Conservancy District, 2016, Zephyr Cove Water Quality Improvement Project, 90% Plans, (12 sheets) dated July 2016.

SITE EXPLORATION AND LABORATORY TESTING

Two hand-dug test pits were excavated in the project footprint on October 20, 2016, from within the footprint of the proposed WQD. Test pits were dug to a depth of 3 feet at each location, and samples were bagged and returned to MDA's office. Soils were uniform throughout the depth of both test pits. The two samples were composited into a single sample which was tested in the laboratory for grain size (ASTM D422) and plasticity (ASTM D4318). Plasticity test results indicate the soils were non-plastic. Laboratory testing in summarized on Plate 1.

RECOMMENDATIONS

Site soils are silty sand with 15 percent fines content on average. These soils are moderately permeable but should not result in embankment leakage if 3H:1V side slopes are used. If the soils are subject to moderate flow velocities (greater than 1 foot per second) or overtopping of the embankment, the soils will be moderately to highly erodible. A dissipation structure should be provided at the inlets, which should be near the bottom of the WQB. WQB berms should be further protected from erosion by establishment of permanent vegetation, and should be protected from future disturbance due to excessive foot or vehicle traffic.

For embankment (berm) construction, all vegetation should be stripped and grubbed from the area to be covered by the embankment. A stripping depth of 0.2 to 0.3 feet is anticipated. Trees and associated roots greater than one-half inch in diameter should be removed, where necessary, to a minimum depth of 12 inches below finished grade or in the footprint of the WQB berm. Stripped soils and natural organic debris may be stockpiled on site and reused in the upper 3 inches of embankment fill, basin bottom and exposed excavation slopes to facilitate vegetation. After stripping and grubbing, the upper 12 inches of exposed soil beneath the berm should be compacted to 88 percent relative compaction per ASTM D1557. Berm fill should be placed, moisture conditioned, and compacted in 12-inch-thick lifts and densified to between 89 to 92 percent relative compaction.

LIMITATIONS

The recommendations contained in this report are based on research and our understanding of the project area and proposed construction. This report has been prepared for design purposes for specific application to the currently proposed subject project in accordance with the generally accepted standards of practice at the time the report was written. If the scope of the proposed construction changes from those described, our recommendations should be reviewed by us and may require modification. No warranty, expressed or implied, is made.

Sincerely,

Marvin E. Davis & Associates, Inc.

PROFESSIONAL ENGINEER - STATE OF NEVADA
JONATHAN W. PEASE
Exp: 12-2017
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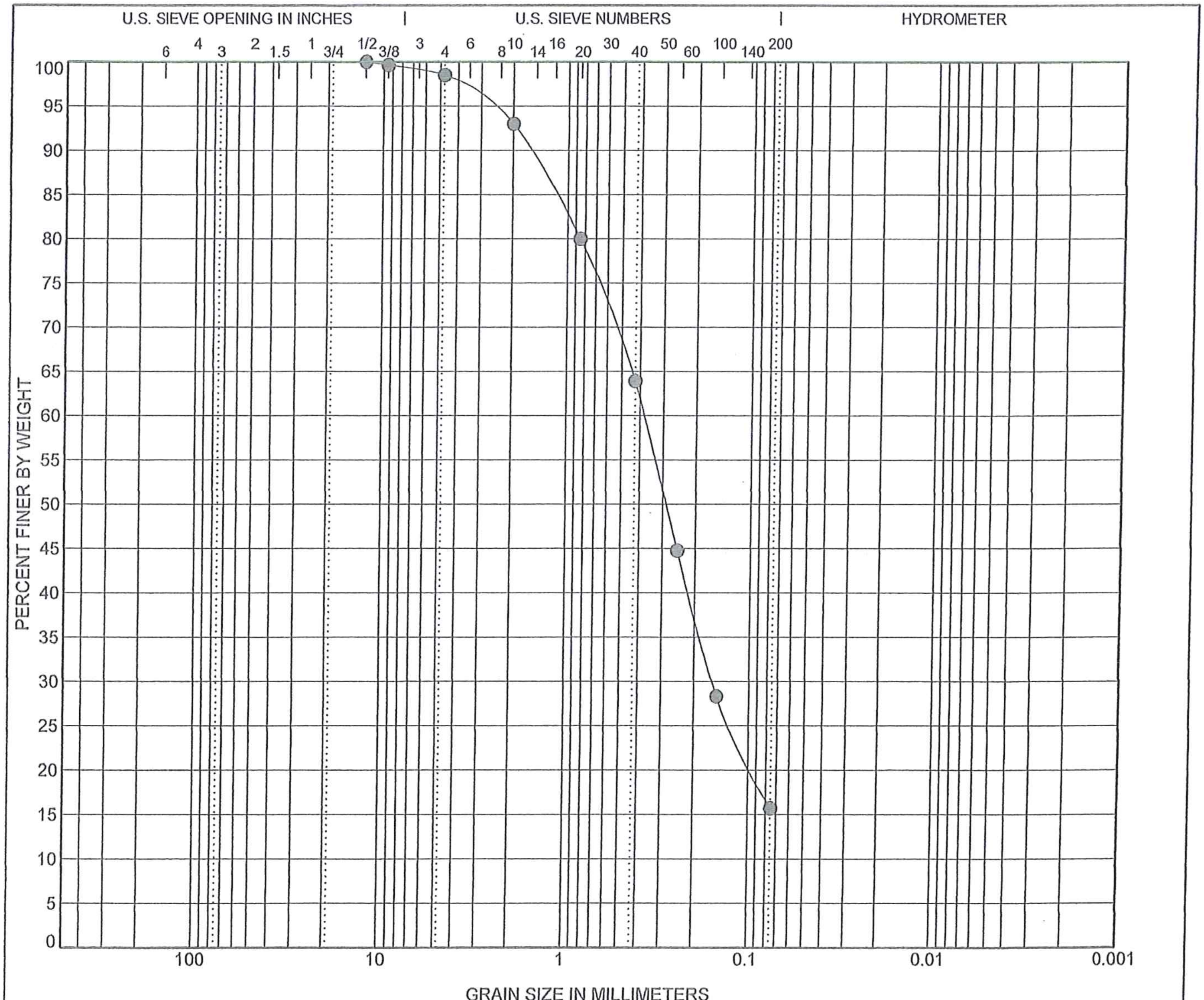
No. 16296

11-8-16

Jonathan W. Pease, Ph.D., P.E.
Associate Engineer, PE 16296 (NV)

Attachments: Plate 1 – Grain Size Analysis



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● TP1&2	3.0	SILTY SAND(SM)	NP	NP	NP		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● TP1&2	3.0	12.5	0.381	0.158		1.5	82.8	15.7	

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JOB # 1669.001 APPR:______ DATE: 10/20/16

GRAIN SIZE ANALYSIS

LABORATORY TESTING
NTCD STORMWATER QUALITY BASIN
ZEPHYR COVE

DOUGLAS COUNTY NEVADA

PLATE 1