TERRITORIAL LANDWORKS, INC.

MEMORANDUM

DATE: April 11, 2019

TO: Missoula City Council & Troy Monroe, P.E.

FROM: Jason Rice, P.E., CEO

RE: Hillview Crossing Townhomes – Storm Water (TLI #14-3592)

Council and Troy,

As was promised at the last LUP Committee meeting, attached to this Memo is an updated stormwater report. We have not included any of the original calculations that did not change as outlined in the text below. Following is a summary of what has been updated and what was not updated, along with our reasoning.

UPDATED: We heard that members of City Council wanted a "Feasibility Level" stormwater report. When we reported that this is what was provided originally, it was clarified that what was of interest is how the water would be stored and conveyed to the City stormwater system. Following is a list of what was revised. Please note that when designing infrastructure that interacts with the City systems, we would prefer to work directly with City Engineering, but understand that we are not allowed to have direct communication outside of the hearings at this time. If this is a misunderstanding or if City Council can direct staff to work directly with us, we would be happy to address any concerns.

1. Per Troy Monroe, PE's email dated October 9, 2018, we revised the pro-rated flow in Section 5.2B. This included removing the area of the property that doesn't contribute to the existing collection ditch. The revised exhibit and calculation show the actual contributing "pro-rated" flow to be 2.57 cfs (not 2.7 cfs as previously submitted).

2. Per Troy Monroe, PE's email dated October 9, 2018, Section 5.2C was amended to include a preliminary analysis showing pipe sizes at different slopes to show how the final pipe sizing will be handled and actually calculated. The full time-intensive calculations are not completed as they depend on final grading and final road design. This spreadsheet instead gives an idea how different pipe sizes can handle different flows at varying slopes. The contributing area to different catch basins and associated storm pipes will be modeled as a system and factor in all upstream and downstream conditions in a future final report.

3. Per previous public comment, the actual existing topography and slope of the site is closer to 15%-30% (not 10%-15%) and the report, specifically Section 3.1A, was updated accordingly for the existing conditions and general slope discussion.

4. As requested by City Council, we evaluated the outlet structure from the stormwater vault that will lead to the park and sized an orifice that will limit stormwater flows as discussed in the original report and amended with this submittal per Troy's email.

5. As requested by City Council, we also have included an exhibit and diagrams of how a vault could store the waters generated by the current proposal. This includes a vault that has been preliminarily analyzed structurally by Eclipse Engineering and an outlet structure orifice that will limit flows to the allowed 2.57 cfs, while storing the required volume.

NOT UPDATED: Given the limited time to turn this report around and the fact that there are still some unanswered questions and requests, we have not included the following updates that may or may not be needed to consider the stormwater design as final:

1. Final Road Design – depending on final mass grading to meet any other changes that may be requested, the street grades may need to be adjusted which could change the location and slope of the storm pipes. Additionally, Council has required that the road width be increased to 35'. However, this makes the project infeasible with 20' setbacks. The Developer's attorney has written a legal memo requesting reconsideration. Given that the calculations have been previously reviewed, this would only increase the storage and flow rates slightly, and therefore, these updates were not completed at this time. Following is a partial list of all the work that will need to be updated upon final decisions:
   - New impervious areas and other surface use area calculation revisions (i.e. asphalt, concrete, gravel, sidewalk, etc.)
   - Curve Number Calculation revisions
   - Time of Concentration revisions
   - TR-55 calculation revisions for Runoff Rates & Runoff Volumes

2. A full Catch Basin & Storm Pipe Analysis has not been completed at this time as requested in Troy's October email for the same reasons above. Currently, we estimate 20 catch basins and an estimated 3430 lineal feet of storm pipe to be analyzed.

3. Final Stormwater Detailing on construction grade plans has not been completed for items including, but not limited to:
   - Stormwater Details (Catch Bains, Pipes, Curb Inlets, etc.)
   - Stormwater Storage Vault Details for Rebar, Backfilling, Compaction, Concrete, etc.

Attachments:
- Updated Preliminary Grading and Drainage Engineering Design Report
- Updated or New Calculations
  - Exhibit Showing Revised Pro-Rated Flow Calculation
  - Orifice Sizing Calculation
  - Example Pipe Flow Calculations for Different Pipe Sizes at Varying Slopes
- Outlet Pipe and Storage Vault Structure Schematic and Site Plan

Copied to: Mary McCrea – City of Missoula Development Services

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PRELIMINARY

GRADING AND DRAINAGE ENGINEERING DESIGN REPORT

FOR CALCULATIONS USING USDA/NRCS WinTR-55 PROGRAM &
IN ACCORDANCE WITH CITY OF MISSOULA PUBLIC WORKS STANDARDS

for

Hillview Crossing
Townhome Development

Located at:
Off of Hillview Way
Section 6, T12N, R19W, P.M.M.
City of Missoula, Missoula County, Montana

Original: September 7, 2018
Revised: October 2, 2018
Revised: April 9, 2019

Prepared For:
City of Missoula
435 Ryman Street
Missoula, MT 59802

Prepared On Behalf Of:
Hillview Crossing Missoula LLC
3605 Arthur Street
Caldwell, ID 83605

Prepared By:
Territorial-Landworks, Inc.
1817 South Ave W, Suite A
P.O. Box 3851
Missoula, MT 59806

1.0 GENERAL

Hillview Crossing is a proposed Townhome Development of approximately 25.6 acres located below and north of Hillview Way in Missoula's South Hills area. The legal description of the property is: Portion of the Southeast ¼, Northeast ¼, Section 6, T12N, R19W, less Wapikiya Addition No. 3, located in the City of Missoula, Missoula County, Montana. As part of the townhome development, there will be a total of 68 separate townhome units. Development will include new roads, sidewalks, a trail, extensions to the public water and wastewater systems, and a stormwater collection and management system will all be required. The proposed development is located on undeveloped land surrounded by urban developments with open space, fair conditioned grassland and steeper slopes.

This storm water report will outline the existing conditions, review the proposed development, summarize the storm water analysis/design, provide the anticipated storm water results and summarize the findings. The pre-developed and post-developed storm water runoff volumes will be calculated. The objective is to manage the storm water flows so that the peak flows for the post-developed conditions that leave the subdivision are not greater than the pre-development flows and ensure that the site drainage functions properly because of the steeper slopes found on-site. Traditional flow paths will be maintained as well as reasonably possible.

This report was prepared based on preliminary discussions with the City of Missoula and in accordance with their requirements, with input from MDEQ Circular 8 for data and methods used.

2.0 DRAINAGE DESIGN CRITERIA AND METHODS USED

The SCS method, also known as the Curve Number method or the TR-55 method, was used to estimate the storm runoff rate for the site and each individual basin, if applicable. For Montana, typically the SCS

Type II Rainfall Distribution is utilized as part of the TR-55 analysis. Both the TR-55 Manual and Chapter 7 of the MDT Hydraulics Manual have been used as references for the SCS method in this report. MDEQ and the City of Missoula requires that the intent of the design for the site is that flows for a 2-year storm will not increase above existing levels, no roads will be overtopped for the 10-year storm, and no property damage (inundation of drainfields or structures) will occur for the 100-year storm.

The runoff volumes and peak flows from the 2-year and 100-year, 24-hour storms were analyzed for both pre-development and post-development conditions.

The primary inputs for the SCS Method are as follows:

- Curve Number: A curve number is selected for the watershed based on the soil texture (hydrologic soil group) and ground cover. Standard tables developed by the NRCS (formerly SCS) are used to select the appropriate number.
- Time of Concentration: The time of concentration is equal to the longest theoretical time for any drop of rain to flow from the point where it lands in the basin to the basin outflow point based on the longest flow path. Calculating a time of concentration involves summing flow times for runoff as sheet flow, shallow concentrated flow, and channel flow, if applicable. With other factors being equal, the shorter the time of concentration, the higher the design peak flows for a basin.
- Watershed/Basin Area: A basin is generally defined as an area which drains to a single point.
- Design Storm Depth: The SCS Method uses 24-hour storm depths developed by the National Oceanic and Atmospheric Administration (NOAA) with a selected design recurrence interval, such as 2, 5, 10, 25, 50, or 100-year storms. NOAA Atlas Maps for Montana are attached.
- Storm Distribution: To evaluate peak flows, it is necessary to select a design storm hyetograph, or rainfall time distribution pattern. TR-55 recommends a Type II design storm for all of Montana. This storm distribution concentrates a majority of 24-hour rainfall within a sharp peak lasting less than one hour. It is the most conservative of the standard SCS hyetographs for calculating peak flows.

The selection of a curve number enables the SCS method to model the capacity of the soil and land cover to capture and infiltrate rainfall. The model is highly non-linear in that relatively small percent increases in rainfall can lead to large increases in runoff, because as the infiltrative capacity of the soil is used up a higher percentage of precipitation will run off. As the SCS method accounts for soil saturation while the Rational Method generally does not, the SCS method may be more accurate in modeling runoff from natural soils and vegetation than the Rational Method.

Note that the TR-55 method has no specific considerations or adjustment for steep slopes and therefore, none are factored in for this site.

3.0 EXTENT OF STORM DRAINAGE

The following information pertains to offsite flow that may affect the proposed development as well as mitigation for storm water flow rates that will be increased due to the development.

3.1 DELINEATION OF DRAINAGE AREAS INSIDE THE SITE (ON-SITE)

3.1A HISTORICAL BASINS

The site is relatively steep (15%-30% slopes) and consists of open space grassland in fair to good condition groundcover. Note the previously discussed limitations of the TR-55 method regarding steeper slopes. Due to the surrounding topography, some off-site flow contributes runoff to this site. This is generally the same as the on-site flows and is considered the area southwest of the site and north of the existing road, Hillview Way. This off-site flow and the historical drainage patterns were considered for the runoff calculations for the site. Due to the off-site flow and the proposed development layout, provisions will be made to pass these flows without entering the development's proposed storm infrastructure.

Any bypass drainage as described above will likely concentrate along the proposed road and then routed along the western property line, under/over and then away from the proposed trail. To remedy the potential for erosion due these concentrated flows, appropriately designed dissipation considerations will be planned for, which could include rip-rap or gravel check dams or other engineered infrastructure specifically for the prevention of hillside erosion.

As part of the property, there is an existing drainage collection swale on the north end of the property (downhill side) that collects runoff from the hillside for the surrounding area and then congregates at a single outlet point. This outlet then flows through an existing pipe down the remaining hillside into an open channel in Wapikiya Park, which from there enters the City of Missoula storm drainage system. As part of the proposed development, if post-development runoff rates and volumes are controlled and released at pre-development rates, then there should be no significant increase in runoff into the park drainage basin and City of Missoula storm infrastructure.

It is understood that the existing ditch/swale on the north (downhill) side of the site and all other existing piping are part of the City of Missoula's storm drainage system and any adjustment to such needs approved by the City before any work is to occur. Although we don't anticipate any major alterations to the City's infrastructure, where the controlled outlet from this proposed development into the City infrastructure (i.e. existing ditch) will need approval upon completion of final designs and construction plans.

3.1B DEVELOPED BASINS

Although the proposed roads and structures will alter the localized drainage patterns on the property, the overall drainage patterns and discharge points from the property will remain the same. The post-development conditions have been classified into five (5) separate drainage basins. The breakdown of the basins is based on these proposed drainage patterns of the proposed roads and structures on the steeper lot. As discussed in the section above, historical drainage patterns will be held, and the localized flow patterns will be collected and contained such that they can be routed to the existing patterns downstream. Collection and mitigation of storm water runoff will be accomplished by drainage infrastructure including (but not limited to) concrete curb and gutter, roadside ditches, catch basins, storm pipe, culverts, and collection ponds/basins.

A breakdown of the development basins with areas of different proposed groundcover are discussed later in this report and attached with curve numbers and basin areas.

3.2 DELINEATION OF DRAINAGE AREAS OUTSIDE THE SITE (OFF-SITE)

The off-site conditions are generally the same conditions as on-site with relatively steep slopes and consists of open space grassland in fair to good condition groundcover. The off-site areas contributing flow that needs accounted for includes some areas southwest of our site and north of the existing Hillview Way. Due to the surrounding topography, some off-site flow contributes runoff to this site. This is generally the same as the on-site flows and is considered the area southwest of the site and north of the existing road, Hillview Way. This off-site flow and the historical drainage patterns were considered for the runoff calculations for the site. Due to the off-site flow and the proposed development layout, provisions will be made to pass these flows without entering the development's proposed storm infrastructure. To plan for this flow, roadside ditch with gravel check dams and culverts to route this flow around or through the site.

4.0 PROVISIONS TO MITIGATE OFF-SITE STORM WATER FLOWS

As described in Section 3.2 of this report, off-site flows into the subdivision are expected due to the existing topography in the area southwest of our site and north of Hillview Way. All off-site flows concentrating to the site are accounted for and will be included in the on-site calculations below and will be mitigated accordingly. Existing drainage patterns will be maintained off-site and on-site.

5.0 PROVISIONS TO MITIGATE ON-SITE STORM WATER FLOWS

The calculations below and attached show that there will be an increase in storm runoff from the proposed development. See the table below for the post-development runoff generated for each basin.

5.1 CALCULATONS & DESIGN

Calculations for this report are based on the SCS Type II Rainfall Distribution for calculating storm water runoff and conducted using the USDA/NRCS TR-55 method. Pre and post-development runoff rates and volumes were determined for the 2-year and 100-year design storms with 24-hour durations. Calculations were made using curve numbers, basins, and time of concentration to ensure proper routing and that any proposed infrastructure is not inundated. Per City of Missoula and standards, the design for the site is that flows for the 100-year storm and developed peak flows are limited to the pre-development flows for the 100-year event. For all calculations, refer to the attached TR-55 calculations.

5.1A HYDROLOGIC SOIL GROUP

The NRCS Soils Data was obtained from the Web Soil Survey website (located at: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) to determine hydrologic soil group (HSG). The NRCS Soils Data for this site shows it to be a combination of Bigarm Gravelly Loam, which is HSG=B and Minesinger-Bigarm Complex, which is HSG=C.

5.1B CURVE NUMBERS & LAND USE DATA

Curve numbers were obtained from the TR-55 Manual, Tables 2-2a, 2-2b, and 2-2c. When there are multiple or combination of hydrologic soil groups, a weighted curve number is determined for the different areas. Due to the existing on-site soil is a combination of HSG B and C (from above) and is primarily groundcover classified as *"pasture, grassland, or range in fair condition,"* the Curve Number (CN) of 69 and 79, respectively for the HSG's was utilized for existing condition in the TR-55 method. For post-development, all proposed impervious infrastructure (i.e. structures, asphalt, concrete, etc.), landscaping (sod, re-seeded), and undisturbed areas were included for the site. See the summary table below and the attached to this report for the data used for this site.

Hydrologic Soil Group (HSG)	B & C	from Web Soil Survey in 4.1A above
Curve Number (CN) – Existing Ground	69	HSG = B for "pasture, grassland, or range in fair condition"
	79	HSG = C for "pasture, grassland, or range in fair condition"
Curve Number (CN) – Impervious Areas	98	standard for impervious (asphalt, concrete, buildings, etc.) from TR-55 for all hydrologic soils groups (HSGs)
Curve Number (CN) – Seeding & Landscape*	61	HSG = B for "open space – good condition, >75% ground cover" or "pasture, grassland, or range in good condition"
	74	HSG = C for "open space – good condition, >75% ground cover" or "pasture, grassland, or range in good condition"

**Note: for the final landscaping/sod/seeding of disturbed areas, the same curve numbers are the same for "open space, good condition (grass cover >75%)" as for "pasture, grassland, or range in good condition" for both HSG 'B' and 'C' (i.e. CN=61 for HSG=B, and CN=74 for HSG=C for both open space lawns and natural looking vegetation that is classified as pasture/grassland/range). Generally, lawn areas are classified by the City as irrigated and mowed, and natural vegetation will be all other landscaped areas, not specifically sodded areas.*

5.1C BASINS AND AREAS

The site was split into five (5) different basins/areas for the drainage areas based on the post-development grading. Each basin has an area associated with it and incorporates the post-development infrastructure such as impervious area (asphalt, concrete, buildings, roads, etc.), landscaping (re-seeded areas), and undisturbed areas. A breakdown of the basin areas with associated groundcover is attached to this report.

5.1D TIME OF CONCENTRATION

Time of concentration was determined by the TR-55 Program and is calculated based on the longest flow path and watercourse slope of the pre-development and post-development conditions for the site and individual basin(s). Time of concentration is broken down into sheet flow, shallow concentrated flow, and channel flow for all pre- and post-development drainage basins. A summary of the calculations is attached showing flow lengths, slopes, and types of flow are attached. Also, time of concentration calculations are attached with the WinTR-55 program inputs/outputs. Note that the minimum allowable value of time of concentration for TR-55 is 0.100 hr. If the calculated value falls below this minimum, the minimum value will be utilized as shown in the WinTR-55 program.

5.1E STORM DATA

The SCS Method uses 24-hour storm depths developed by the National Oceanic and Atmospheric Administration (NOAA) with a selected design recurrence interval, such as 2, 5, 10, 25, 50, or 100-year storms. The state of Montana uses the Atlas 2 method. Also, the MDT and MDEQ have published specific storm data for specific sites through the state. Also, there is a NOAA website that allows for site specific precipitation values for the 2-year and 100-year storms from NOAA Atlas 2, which can be deemed more accurate. Using the NOAA website (http://www.nws.noaa.gov/ohd/hdsc/noaaatlas2.htm) with a site specific latitude/longitude of 46.8285°N, -114.0282°W provides the following precipitation amounts and intensities:

	Design Storm (24-hour)	
	2-year	**100-year**
Precipitation Amount (in)	1.20	2.58
Precipitation Intensity (in/hr)	0.05	0.11

5.1F INPUTS FOR WinTR-55 PROGRAM

The values described in Section 5.1 above are input into the WinTR-55 program to determine the runoff rate and volume of the pre- and post-development basins. See the attached printout of the WinTR-55 Input data showing variable inputs.

5.2 STORMWATER MANAGEMENT & CALCULATION OUTPUTS

On-site collection of stormwater runoff is planned to contain the runoff from the design storm. Detention will be required if the site was to hold the change in runoff from the pre-development vs. post-development for the 100-year, 24-hour storm runoff and meet the requirements for both storage and flowrate. Site constraints and surrounding topography determine the stormwater management requirements. For this specific site, the proposed collection and stormwater management is discussed later in this report.

5.2A RUNOFF VOLUMES AND RUNOFF RATES (WinTR-55 Results)

After using the TR-55 Method by inputting values into the WinTR-55 Program, the analysis was run and calculated the flow rates for the storm event(s) analyzed for this project. A summary of the results is presented below, with the WinTR-55 program output pages and drainage summaries attached.

Pre or Post	Basin	Runoff Volume (V) (cf)	Runoff Rate (Q) (cfs)
		100-yr	100-yr
Pre	On-Site	50,940	17.93
Pre & Post	Off-Site	26,921	9.66
Post	1	14,653	5.50
Post	2	13,957	6.01
Post	3	15,909	6.73
Post	4	12,579	4.80
Post	5	11,235	3.93

As is demonstrated by the calculations, the development will increase the stormwater runoff from the site generally due to the increase of additional impervious areas (asphalt, buildings, gravel, etc.). The higher post-development runoff volume than pre-development means containment and conveyance is required.

Note, that since this is preliminary planning for this development to determine magnitudes of runoff rates and volumes for preliminary sizing of stormwater infrastructure. As final grading occurs, basins may change slightly, and calculations will need updated. Different or additional drainage mitigation design will be required for the basins in this case. As for now, the site will utilize curb, catch basins, storm pipe, and containment areas (i.e. swales or ponds) are planned for the associated post-development runoff.

Full preliminary calculations and summaries are attached.

5.2B GENERAL STORMWATER DESIGN – ON-SITE

To meet the requirement to not exceed the pre-development runoff rates and due to site constraints, the proposed stormwater design will be to mitigate the difference in pre-development and post-development runoff rates and volumes for the 100-year, 24-hour storm event. A storm drainage collection system of curb, catch basins, storm piping, swales and collection pond(s) will route post-development runoff throughout the site. All roof drains from the proposed structures will tie into the proposed storm drainage system to prevent excess runoff on the finished ground surface so not to inundate structures or surface infrastructure.

Catch basins with storm pipe that outlet to culverts are planned to route the stormwater runoff from the design storm. Future calculations will follow to size the proposed storm pipes between catch basins and ensure the existing downstream culvert is adequate to handle the increase of runoff flow rates from the post-development site.

Basin 1

Runoff will route on the south-eastern portion of the site and then west down the curb line and storm drainage system and combine with Basin 2 stormwater runoff at the mainline of the storm drainage system that runs south-to-north down the hillside between the townhomes.

Basin 2
Includes the road from Hillview Way and eventually catches the storm drain, which will combine with the stormwater flow from Basin 1 at the storm drainage system that runs south-to-north down the hillside between the townhomes.

Basin 3
Includes the south-western stormwater runoff and follows the proposed curb into the storm drainage system via inlets, then routes through the storm drainage system (catch basins and piping) to a junction point at a proposed catch basin that runs south-to-north down the hillside between the townhomes. This junction point will also need to consider the stormwater flow from Bains 1, 2, and 4 as all stormwater congregates at this point.

Basin 4
Includes the middle-eastern stormwater runoff and follows the proposed curb into the storm drainage system via inlets, then routes through the storm drainage system (catch basins and piping) to a junction point at a proposed catch basin that runs south-to-north down the hillside between the townhomes. This junction point will also need to consider the stormwater flow from Bains 1, 2, and 3 as all stormwater congregates at this point. This will be considered the last point before release of runoff at pre-development rates.

Basin 5
Will be the runoff associated with the backside (downhill) of the entire development. This accounts for developed lawn areas and the undisturbed areas, including the existing drainage collection swale that outlet through Wapikiya Park. Additionally, this includes the area to the western side of the site where a future gravel trail will be constructed. This basin generally runs off-site without being collected.

Off-Site
Off-site stormwater runoff calculations will remain the same both pre- and post-development since no changes will occur off-site, meaning no increase in runoff. However, mitigation will be required to prevent runoff into the development. Generally, the off-site will be caught in the roadside ditch and routed around the subdivision on the western side to avoid the mitigation on-site in the proposed storm drainage system. The utilization of a roadside ditch with gravel check dams and culverts will help route stormwater flow through and around the site.

Summary
Based on the calculations in Section 5.2A above, provisions will need to be made to contain the excess runoff from post-development compared to pre-development. Due to Basin 5 automatically running off to the existing drainage swale down the hill to the north, it counts against the post-development containment requirement. The requirement to limit post-development runoff to pre-development runoff rates requires analysis of what automatically leaves the site versus what is collected on-site. From the above (and attached summary):

Runoff Rates
Pre-Development (On-Site) = <u>17.93 cfs</u>
Post-Development Flow (Basin 1-4) = <u>23.04 cfs</u>
Post-Development Flow (Basin 5) = <u>3.93 cfs</u>

Max. post-development release (total pre-development rate) = <u>17.93 cfs</u>

Max. remaining post-development release due to Basin 5 = 17.93 cfs – 3.93 cfs = **14.00 cfs**

Runoff Volumes
Pre-Development (On-Site) = 50,940 CF
Post-Development (Basin 1-4) = 57,099 CF
Post-Development (Basin 5) = 11,235 CF

Difference that needs to be detained on-site = 57,099 CF + 11,235 – 50,940 CF = **17,393 CF**

The site will utilize a stormwater storage vault, exact placement to be determined upon completion of construction plans, that holds this required volume.

The storage volume of the stormwater vault as shown on attached exhibits or details is shown calculated here:

Interior Length Dimension of Storage Vault (Entire Length) = 122.67 feet
Thickness & Number of Interior Walls = 4 interior walls @ 8" (0.67') thick each
Total Usable Length for Volume = 122.67' – (4*0.67) = 120 feet
Interior Width Dimension of Storage Vault = 20 feet
Effective Vault Depth (from bottom of tank to top of outlet overflow pipe) = 7.5 feet

Actual Stormwater Vault Storage Volume = (120 feet) * (20 feet) * (7.5 feet) = **18,000 CF**

Stormwater will exit the storage vault via the orifice discussed below and the outlet pipe inside the vault and down the hill towards the existing collection ditch. At that point, a dissipation structure at the outlet near the existing ditch will slow down the flow and direct it towards the existing inlet structure and pipe in the collection ditch.

In discussions with the City of Missoula, it was determined that the maximum design flow for the existing 18-inch pipe into Wapikiya Park is 7 cfs from previous City of Missoula design models. Because this existing design flow (7 cfs) is for the entire hillside where the existing drainage ditch contributes (i.e. more than just the proposed development site area), we need to "pro-rate" the ratio of existing design flow from our site versus the entire design flow (the 7 cfs).

To perform this "pro-rated" ratio of our site's contribution to the design flow, we analyzed aerial and topographic imaging to determine that total hillside contributing area to the existing drainage swale and outlet into Wapikiya Park. An exhibit is attached showing the determined contributing area and site area and a summary of the pro-rated calculation shown here:

"Pro-Rated" Outlet Design Flow to City of Missoula Existing Drainage Infrastructure
Existing Design Outlet Flow to Wapikiya Park = 7 cfs (provided from City of Missoula)

Total Contributing Area to Existing City of Missoula Drainage Ditch = 66.5 acres

Total Development Property Area = 25.6 acres

Total Property Area Below Existing Ditch at NE corner (Not Contributing) = 1.1 acres

Total Proposed Development Site Contributing Area to Existing Ditch = 24.5 acres

Percentage of Contributing Flow from Proposed Development Area versus Overall Contributing Flow to Existing Ditch = (24.5 acres) / (66.5 acres) = 36.8%

Allowable "pro-rated" flow to be released from the site = (7 cfs)*(36.8%) = **2.57 cfs**

An outlet pipe or orifice will be sized so not to exceed the "pro-rated" flow rate of **2.57 cfs** (from above). An orifice was sized based on the maximum head over the orifice. The larger the head over the orifice, the larger the flow through the orifice. The distance was utilized from the centerline of orifice to the top of outlet stand pipe. See the attached analysis showing that a **5.94-inch orifice** is the maximum diameter so that the outlet flow will not exceed the pro-rated flow shown above.

Although it is unlikely that much sediment or debris will make it to the outlet structure within the vault, anything can happen. The top of outlet pipe will be left open so that once the vault fills up, flow could overflow directly into this pipe rather than overtopping the vault wall to avoid any degradation to the vault wall backfill.

As is shown on the hydrographs developed by the WinTR-55 program for the pre-development on-site conditions and the post-development on-site conditions (Basins 1-4), the peak occurs at generally the same time near the mid-storm at 12 hours. See the attached hydrographs.

5.2C STORM PIPE SIZING AND OUTLET

Site Outlet – Pond/Final Collection Area to Existing City of Missoula Infrastructure

As described above, the final collection area (i.e. pond or vault, exact TBD) collects all interior storm drainage from the catch basins and storm piping. The collection area will be designed to detain the difference in runoff volume between pre and post-development. The outlet from the detention infrastructure will be designed to be released only at the "pro-rated" flow rate previously described in Section 5.2B of this report. This will limit and prevent adverse effects on the existing City of Missoula drainage infrastructure.

Site Interior – Catch Basin to Catch Basin

Catch basins with storm pipe that outlet to culverts are planned to route the stormwater runoff from the design storm. Future calculations will follow to size the proposed storm pipes between catch basins and ensure the existing downstream culvert is adequate to handle the increase of runoff flow rates from the post-development site.

The basin breakdown will be clearly defined in the post-development grading with the different curb collection and catch basin locations. Each catch basin had its individual contributing basin, and as it moves downstream, may have other contributing basins from upstream.

A detailed analysis will be prepared to show the interaction between the contributing flow areas to the receiving catch basins and associated storm pipes, while analyzing upstream and downstream conditions. Different pipe sizes will be analyzed to determine their maximum flow capacity. Often, especially on steep sites with tight drainage areas, "free-board" or factor-of-safety can be applied by assuming a percentage flowing full. For future storm pipe calculations, ample free-board will be assumed, with standard practice assumptions of 75%-80% flowing full. Note that is only for pipes interior to the project. All interior site piping eventually collects at the stormwater vault area. This on-site stormwater vault then outlets only at the "pro-rated" flow rate previously described in Section 5.2B of this report.

Pipe capacities will still depend on slopes of the pipe between catch basins, which will be determined upon final site grading. See the attached spreadsheet "Pipe Flow Calculations" that shows, preliminarily, how different pipe sizes and different flow full capacities can be utilized to carry the required flows. This spreadsheet will be included with the future report for all catch basin pipe sizing calculations. Additionally, pipe entrance losses will be included in an analysis to evaluate and ensure no excess flows affect upstream or downstream conditions. We anticipate pipe sizes to vary between 12-inch minimum and 24-inch diameter. As is shown by the attached spreadsheet, pipe capacity varies depending on slope of the pipe. As this is unknown until final grading, pipe sizes throughout the storm drain system cannot be determined or finalized at this time.

Based on the above maximum flow rates for different size storm pipes, the outlet storm pipe from the different catch basins can be analyzed. An example of the breakdown of the future selected outlet storm pipe from each catch basin is as follows:

EXAMPLE ONLY– Future Catch Basin Storm Pipe Sizing

Basin	Peak Flow Rate at Outlet of CB (cfs)	Inlet Storm Pipe Size (inches)	Outlet Storm Pipe Size (inches)
CB #1	TBD	N/A – first catch basin	TBD
CB #2	TBD	TBD	TBD
CB #3	TBD	TBD	TBD
CB #4	TBD	TBD	TBD

Refer to the Civil Construction Plans for drainage patterns and finished grading with locations of catch basins, storm piping, culverts, concrete cove gutter and other drainage infrastructure.

5.3 STORMWATER DISCHARGE TO GROUND

Generally, the TR-55 method accounts for some infiltration due to the curve number based on groundcover and hydrologic soil group conditions. Other than the infiltration accounted for using this drainage analysis method, no infiltration is planned, and the collection to containment of stormwater runoff will be utilized.

6.0 EROSION CONTROL

Erosion control will likely be required due to the size of the site and to ensure no excess sediment leaves the site. With the existing site topography and proposed grading, high flow velocities are a potential and stormwater infrastructure will be designed to handle these flows and mitigate them as much as possible. Any excess sediment generated from the site will be collected and allowed to settle in catch basins or collection ponds, depending on the final site design.

If a stormwater pollution prevention plan (SWPPP) will be required through the Montana Department of Environmental Quality (MDEQ) and/or the City of Missoula, it will be the responsibility of the Contractor (or owner if previously agreed upon) to prepare, obtain, and administrate a SWPPP and any other erosion control permits required by the City of Missoula.

7.0 CONCLUSIONS

This report and drainage calculations are considered preliminary to understand the magnitude of stormwater rates and volumes. A future final grading and drainage report will be completed that will include final sizing of stormwater collection areas, catch basin sizing, storm pipe sizing, and outlet sizing such that runoff volumes are contained, and that post-development runoff leaves the site only at pre-development rates. Final site grading will be required before the final drainage calculations can be completed. Other existing drainage patterns in non-disturbed (i.e. drainage collection swale) or off-site (i.e. property to the southwest) areas will be maintained with flows being routed to these areas. All drainage will be directed away from any proposed structures and the site is graded so that the building will not be affected.

It is understood that the existing ditch/swale on the north (downhill) side of the site and all other existing piping are part of the City of Missoula's storm drainage system and any adjustment to such needs approved by the City upon completion of final designs and construction plans, and prior to any work occurring on-site.

Because this report is preliminary, the calculations shown herein could change depending on final site conditions and grading.

All construction will be in accordance with the final Construction Plans, Montana Public Works Standard Specifications (MPWSS), City of Missoula requirements, and MDEQ regulations, as required.

Prepared by:
TERRITORIAL-LANDWORKS, INC.

Andrew Mill, E.I.

Reviewed by:
TERRITORIAL-LANDWORKS, INC.

Jason Rice, P.E.

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LIST OF ATTACHMENTS (only the highlighted items are included at this time)

- Drainage Exhibits with Basin Delineation *(2 total sheets)*
  - Pre-Development Conditions Exhibit *(1 sheet)*
  - Post-Development Conditions Exhibit *(1 sheet)*
- Drainage Flow Pro-Rated Exhibit *(1 page)*
- "Preliminary Drainage Calculations" Spreadsheet *(3 pages)*
- NRCS Soils Data – Hydrologic Soil Group *(4 pages)*
- Precipitation Frequency Data Output NOAA – Site Specific Precipitation *(1 page)*
- TR-55 Tables 2-2a, 2-2b, 2-2c for Curve Numbers *(3 pages)*
- Orifice Sizing for Outlet Release Structure Spreadsheet *(1 page)*
- "Pipe Flow Calculations" Spreadsheet *(2 pages)*
- Manning's Roughness Coefficients *(1 page)*
- WinTR-55 Input Data *(4 total pages)*
  - Identification Data, Sub-Area Data, Storm Data *(1 page)*
  - Sub-Area Summary Table *(1 page)*
  - Sub-Area Land Use and Curve Number Details *(1 page)*
  - Sub-Area Time of Concentration Details *(1 page)*
- WinTR-55 Output Data *(2 total pages)*
  - Watershed Peak Table *(1 page)*
  - Hydrograph Peak/Peak Time Table *(1 page)*
  - Hydrograph – Pre-Development *(1 page)*
  - Hydrograph – Post-Development *(1 page)*
- WinTR-20 Output Data – Runoff Volumes *(60 pages)*
- Preliminary Storm Water Collection Vault Exhibit *(1 page)*
- ~~Civil Construction (Grading & Drainage) Plans *(attached separately)*~~ **Not complete or included yet**

INCLUDED BY REFERENCE

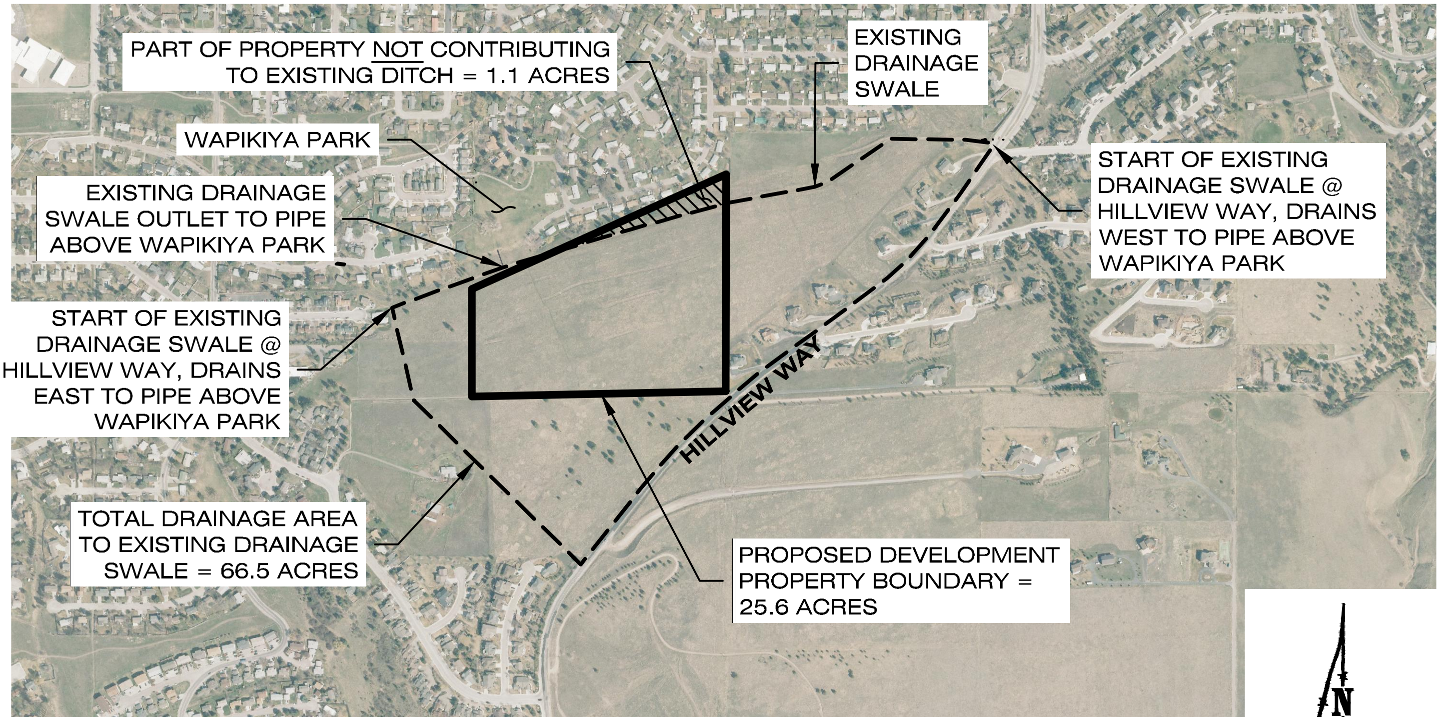
USDA NRCS TR-55 Urban Hydrology for Small Watersheds Manual *(June 1986)*
WinTR-55 Program *(version 1.00.10)*
WinTR-55 User Guide – Small Watershed Hydrology *(January 2009)*
Montana Department of Transportation Drainage Manual
Montana Public Works and Specifications *(latest edition)*
Missoula County Public Works Manual *(January 2010)*
Montana Department of Environmental Quality Circular 8 *(2017 Edition)*

DRAINAGE PRO-RATED FLOW TO OUTLET (LEAVE SITE) INTO SWALE

EXISTING OUTLET FLOW FROM EXISTING DITCH = 7 CFS

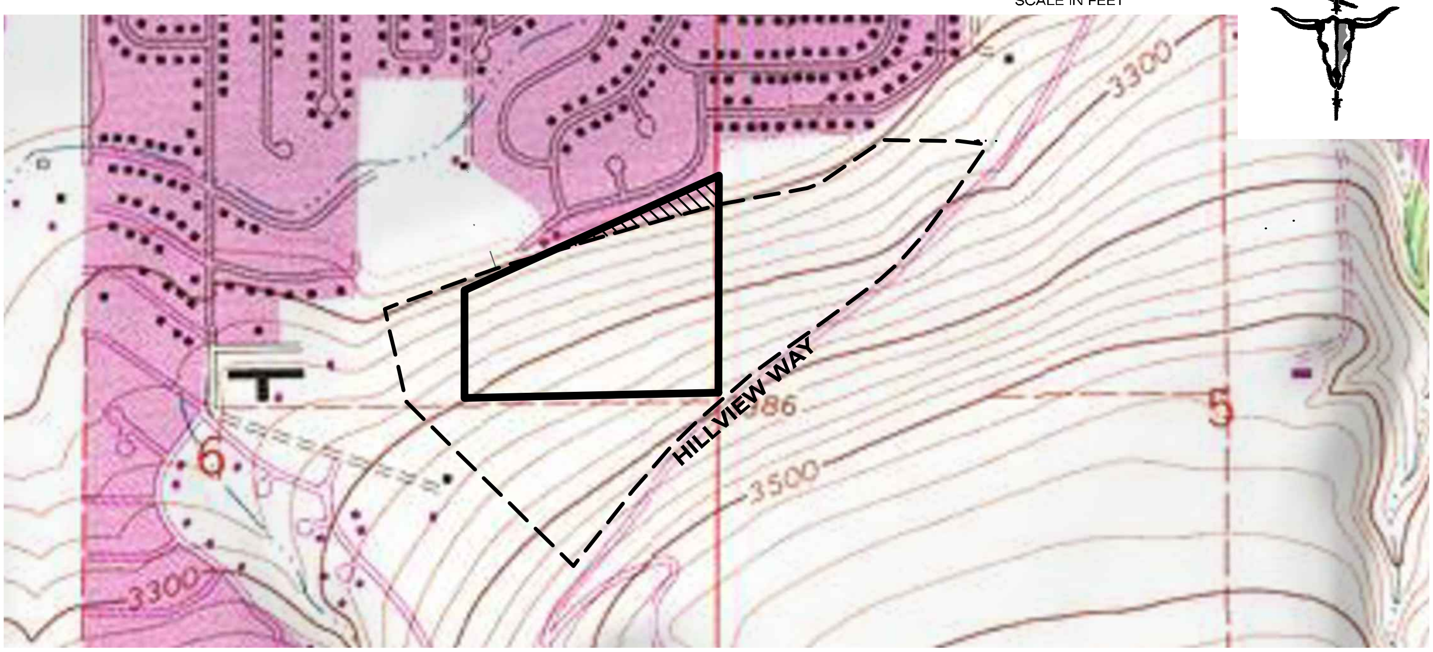
PERCENTAGE OF CONTRIBUTING FLOW FROM PROPOSED DEVELOPMENT AREA VERSUS OVERALL CONTRIBUTING FLOW TO EXISTING SWALE = (25.6 ACRES - 1.1 ACRES)/(66.5 ACRES) = 36.8%

ALLOWABLE PRO-RATED FLOW TO BE RELEASED FROM SITE = (7 CFS)*(36.8%) = 2.57 CFS



AERIAL MAP

500 0 500 1000
SCALE IN FEET



USGS TOPOGRAPHIC MAP

TERRITORIAL LANDWORKS, INC.
Civil Engineering • Surveying • Land Use Consulting
Ph: (406) 721-0142
Fax: (406) 721-5224
www.territoriallandworks.com
PO Box 3851
Missoula, MT 59806

DRAINAGE FLOW PRO-RATED MAP
HILLVIEW CROSSING TOWNHOMES
CITY OF MISSOULA
SECTION 6, T12N, R19W, P.M.M.
MISSOULA COUNTY, MONTANA

PROJECT#: 14-3592
TAB: PRO-RATED FLOW
DRAFTER: AM
DATE: 4/9/2019
SHEET 1 OF 1

PLOT DATE: 4/9/2019 12:33 PM DWG LOCATION: T:\1 ACTIVE FILES\2014 PROJECTS\3592 - HILLVIEW CROSSING-MISSOULA S HILLS DEVELOPMENT\3 DRAFTING\3.1 DRAWINGS\AUTOCAD\MISC DRAWINGS\EXH-14-35_2-DRAINAGE (2019-04-09).DWG

ORIFICE SIZING FOR OUTLET RELEASE STRUCTURE

PROJECT: Hillview Crossing Development, City of Missoula, MT (TLI #14-3592)

DEVELOPER/OWNER: Hillview Crossing LLC

PREPARED BY: Territorial-Landworks, Inc.

DATE: 4/9/2019

VARIABLE SUMMARY

$Q = C_d*A(2gh)^{0.5}$ Orifice equation from McGraw-Hill Water and Wastewater Calculatios Manual

C_d = unitless, coefficient of discharge, value is 0.62 typical for sharp-edged orifice (circular)

g = 32.174 ft/s^2, acceleration due to gravity

h = feet, head over centerline of orifice

A = feet^2, area of orifice ($\pi*r^2$)

Q_{ST} = cfs, sub-total flow through orifices

Q_T = cfs, total flow through orifices

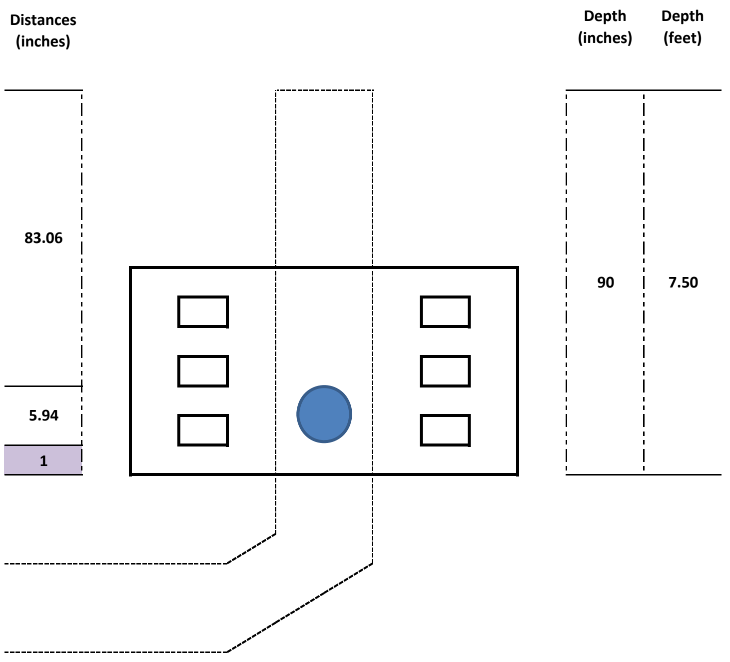
O_n = Number of orifices

q_o = cfs, target release rate from pond sizing (usually a pre-development flow rate)

(purple)	user input
(green)	acceptable value
(red)	un-acceptable value

	Orifice Sizing		
Orifice Diameter =	5.94	inches	
C_d =	0.62		
dist. to next orifice	83.06	inches	distance from top of orifice to top of overflow pipe
h =	86.03	inches	
A =	0.19	ft^2	
Q =	2.56	cfs	
O_n =	1	orifice(s)	number of orifices
Q_{ST} =	2.56	cfs	flow through an individual orifice
Q_T =	2.56	cfs	total flow through total number of orifice(s)
q_o =	2.57	cfs	maximum flow rate based on pro-rated flow
Acceptable Release?	YES		

OUTLET STRUCTURE SCHEMATIC (not to scale)



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Pipe Flow Calculations

Notes:

[1] flow depth based on % flowing full and radius of pipe

[2] cross-sectional flow area of pipe at flow depth

[3] wetted perimeter based on pipe size and flow depth

[4] Manning's n-value based on pipe type: PVC = 0.011, PE = 0.012, RCP = 0.011-0.013

[5] Pipe velocity is calculated using Manning's equation: V = [(1.49*r^(2/3)*s^(1/2)] / n; where r=hydraulic radius (flow area/wetted perim.), s=slope (ft/ft)

[6] Pipe flow is the maximum flow at the pipe depth, calculated as Q=v*A, where v=pipe velocity and A=cross-sectional flow area

Pipe Size (inches)	Pipe Size (feet)	% Flowing Full	Flow Depth (feet)[1]	Cross-Sectional Flow Area (sf)[2]	Wetted Perim. WP (feet)[3]	Pipe Type	Manning's n-value[4]	Pipe Slope (%)	Manning's Eqn. Pipe Velocity (ft/s)[5]	Pipe Flow Qmax (cfs)[6]
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	0.50%	4.30	2.718
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	1.00%	6.08	3.845
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	2.00%	8.60	5.437
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	3.00%	10.54	6.659
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	5.00%	13.60	8.597
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	10.00%	19.24	12.157
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	15.00%	23.56	14.890
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	20.00%	27.20	17.193
12	1.00	75%	0.75	0.632	2.10	PVC	0.011	25.00%	30.42	19.223
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	0.50%	3.80	2.984
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	1.00%	5.38	4.220
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	2.00%	7.60	5.968
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	3.00%	9.31	7.309
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	5.00%	12.02	9.436
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	10.00%	17.00	13.344
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	15.00%	20.82	16.343
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	20.00%	24.04	18.871
12	1.00	100%	1.00	0.785	3.14	PVC	0.011	25.00%	26.88	21.099
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	0.50%	5.00	4.952
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	1.00%	7.07	7.003
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	2.00%	9.99	9.904
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	3.00%	12.24	12.129
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	5.00%	15.80	15.659
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	10.00%	22.35	22.145
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	15.00%	27.37	27.122
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	20.00%	31.60	31.318
15	1.25	75%	0.94	0.991	2.63	PVC	0.011	25.00%	35.33	35.015
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	0.50%	4.41	5.409
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	1.00%	6.23	7.649
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	2.00%	8.82	10.817
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	3.00%	10.80	13.249
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	5.00%	13.94	17.104
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	10.00%	19.71	24.188
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	15.00%	24.14	29.625
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	20.00%	27.88	34.207
15	1.25	100%	1.25	1.227	3.93	PVC	0.011	25.00%	31.17	38.245
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	0.50%	5.65	8.083
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	1.00%	7.99	11.431
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	2.00%	11.30	16.165
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	3.00%	13.84	19.798
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	5.00%	17.86	25.560
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	10.00%	25.26	36.147
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	15.00%	30.94	44.270
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	20.00%	35.72	51.119
18	1.50	75%	1.13	1.431	3.16	PVC	0.011	25.00%	39.94	57.153
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	0.50%	4.98	8.804
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	1.00%	7.05	12.450
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	2.00%	9.96	17.607
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	3.00%	12.20	21.564
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	5.00%	15.76	27.839
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	10.00%	22.28	39.371
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	15.00%	27.29	48.219
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	20.00%	31.51	55.679
18	1.50	100%	1.50	1.767	4.71	PVC	0.011	25.00%	35.23	62.251

Pipe Flow Calculations

Notes:

[1] flow depth based on % flowing full and radius of pipe

[2] cross-sectional flow area of pipe at flow depth

[3] wetted perimeter based on pipe size and flow depth

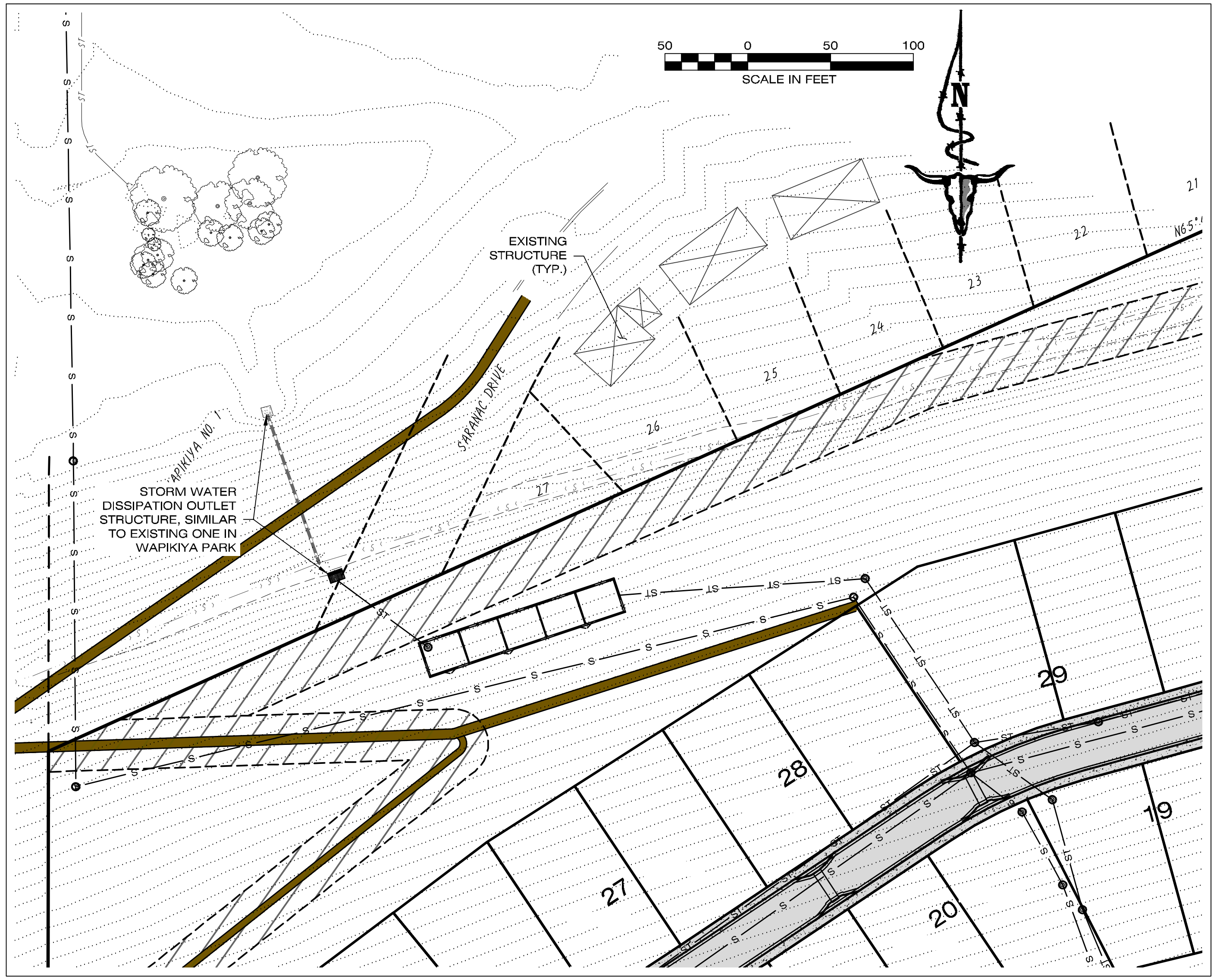
[4] Manning's n-value based on pipe type: PVC = 0.011, PE = 0.012, RCP = 0.011-0.013

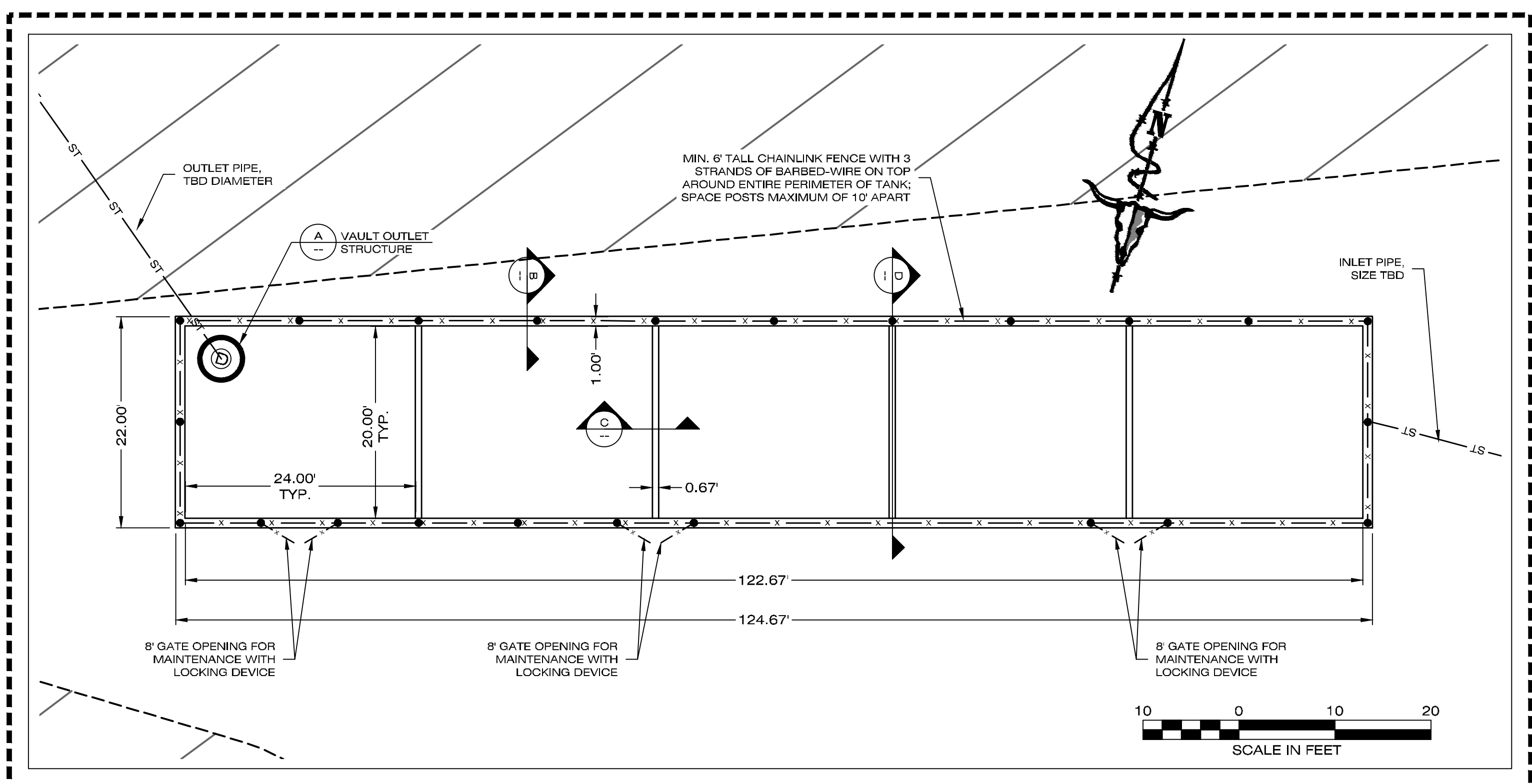
[5] Pipe velocity is calculated using Manning's equation: V = [(1.49*r^(2/3)*s^(1/2)] / n; where r=hydraulic radius (flow area/wetted perim.), s=slope (ft/ft)

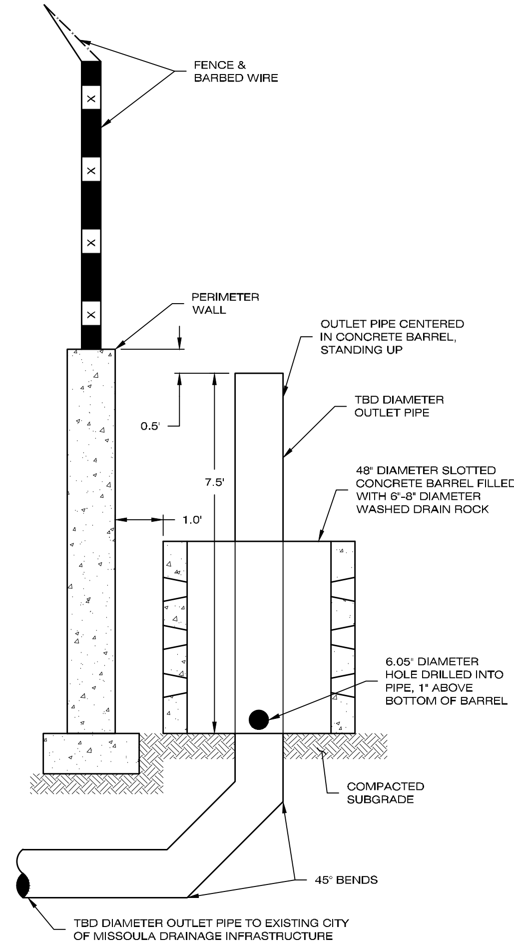
[6] Pipe flow is the maximum flow at the pipe depth, calculated as Q=v*A, where v=pipe velocity and A=cross-sectional flow area

Pipe Size (inches)	Pipe Size (feet)	% Flowing Full	Flow Depth (feet)[1]	Cross-Sectional Flow Area (sf)[2]	Wetted Perim. WP (feet)[3]	Pipe Type	Manning's n-value[4]	Pipe Slope (%)	Manning's Eqn. Pipe Velocity (ft/s)[5]	Pipe Flow Qmax (cfs)[6]
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	0.50%	6.25	12.106
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	1.00%	8.84	17.121
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	2.00%	12.51	24.213
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	3.00%	15.32	29.654
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	5.00%	19.77	38.283
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	10.00%	27.97	54.141
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	15.00%	34.25	66.309
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	20.00%	39.55	76.567
21	1.75	75%	1.31	1.936	3.67	PVC	0.011	25.00%	44.22	85.604
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	0.50%	5.52	13.271
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	1.00%	7.80	18.768
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	2.00%	11.04	26.541
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	3.00%	13.52	32.507
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	5.00%	17.45	41.966
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	10.00%	24.68	59.349
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	15.00%	30.22	72.687
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	20.00%	34.90	83.932
21	1.75	100%	1.75	2.405	5.50	PVC	0.011	25.00%	39.02	93.838
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	0.50%	6.84	17.289
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	1.00%	9.67	24.450
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	2.00%	13.68	34.578
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	3.00%	16.75	42.349
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	5.00%	21.63	54.672
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	10.00%	30.58	77.318
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	15.00%	37.46	94.695
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	20.00%	43.25	109.344
24	2.00	75%	1.50	2.528	4.19	PVC	0.011	25.00%	48.36	122.250
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	0.50%	6.04	18.966
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	1.00%	8.54	26.822
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	2.00%	12.07	37.933
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	3.00%	14.79	46.458
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	5.00%	19.09	59.977
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	10.00%	27.00	84.820
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	15.00%	33.06	103.883
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	20.00%	38.18	119.953
24	2.00	100%	2.00	3.142	6.28	PVC	0.011	25.00%	42.68	134.112

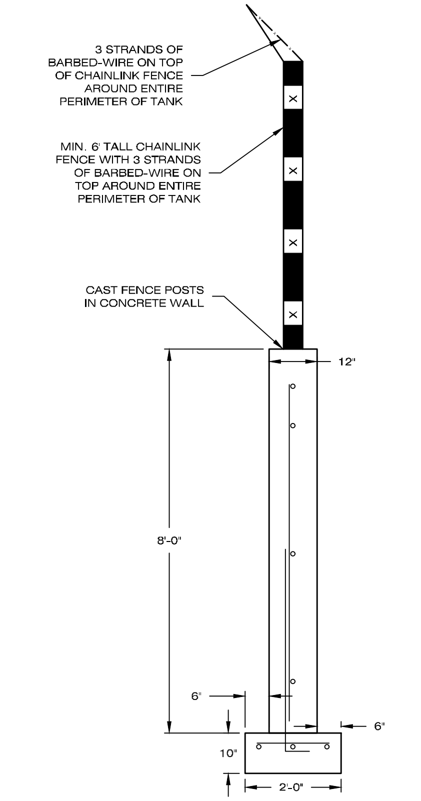
**Values are calculated on flow as pipe-full from the AutoCAD Hydraflow Express pipe modeling software*



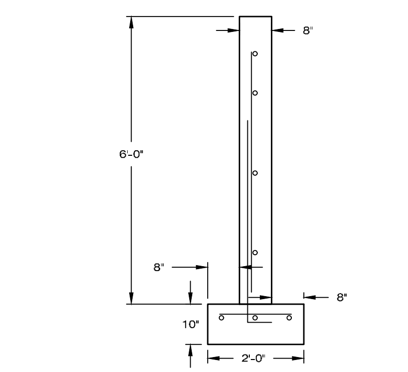




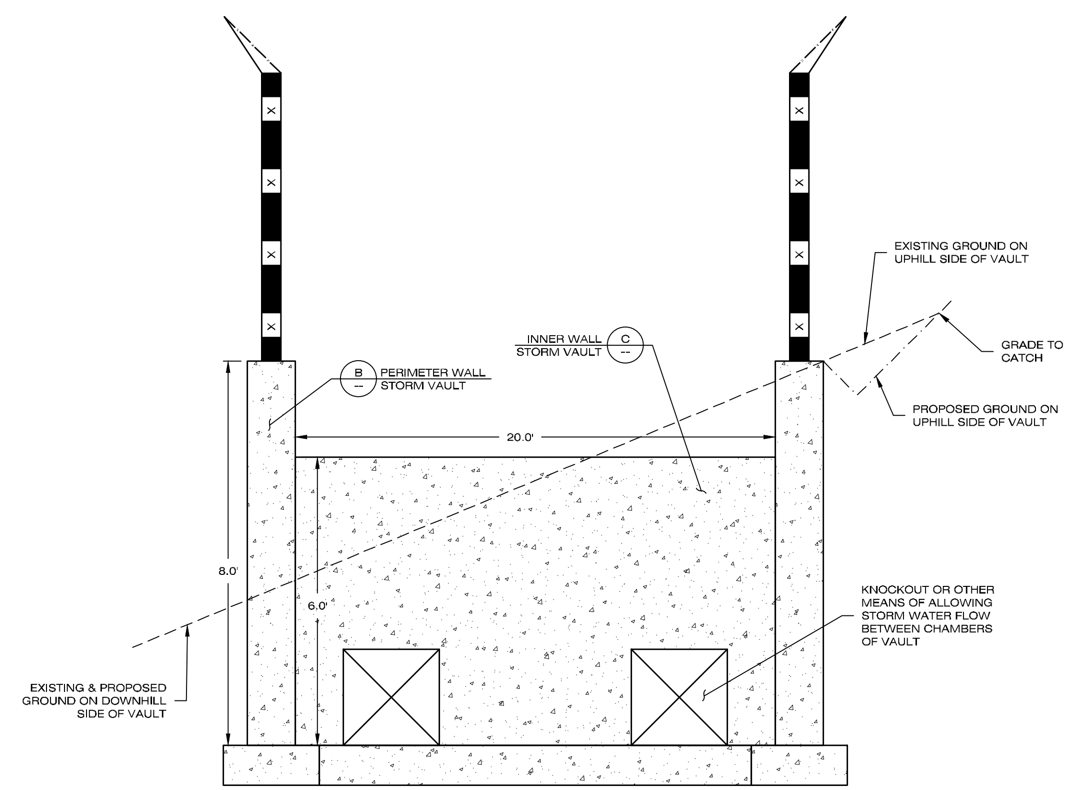
A -- OUTLET STRUCTURE DETAIL
STORM VAULT
NOT TO SCALE



B -- PERIMETER WALL
STORM VAULT
NOT TO SCALE



C -- INNER WALL
STORM VAULT
NOT TO SCALE



D -- INNER WALL - SIDE VIEW
STORM VAULT
NOT TO SCALE

TERRITORIAL LANDWORKS, INC.
CIVIL ENGINEERING • SURVEYING • LAND USE CONSULTING
www.TerritorialLandworks.com
P.O. Box 3851
Missoula, MT 59806
Ph: 406/721-0142
Fax: 406/721-5224

PLOT DATE: 4/9/2019 12:13 PM

REVISIONS	DATE

DESIGNED:
DRAFTED: AM
CHECKED:
DATE: 4/9/2019

LOCATION:
HILLVIEW WAY
SECTION 6, T12N, R19W, P.M.M.
CITY OF MISSOULA
MISSOULA COUNTY, MONTANA

PREPARED FOR:
HILLVIEW CROSSING LLC

PROJECT NAME:
HILLVIEW CROSSING TOWNHOMES

SHEET TITLE:
STORMWATER COLLECTION VAULT EXHIBIT

PROJECT NO.
14-3592

SHEET:
1 OF 1

PRELIMINARY