Section 1. Purpose and Applicability

It is the purpose of this Criteria Manual to preserve and enhance the desirability of our City by requiring careful planning of our City's redevelopment which includes the management of our drainage facilities and storm water while ensuring the owners' rights to utilize and develop their property. In accordance with the City's drainage ordinance, the runoff shall be limited to existing conditions for the 10 and 100 year frequency storm events.

All drainage plans and construction shall meet or exceed the requirements of the City of Bunker Hill Village (hereinafter simply "Bunker Hill") and all other entities having jurisdiction. The goal of this criteria is to provide storm sewer capacity for the 10 year storm event and for the 100 year sheet flow event without increasing the existing condition discharges and not creating adverse impacts to others.

The intent of these drainage standards is to reduce or prevent structural flooding as a result of storm events up to the 100 year storm through the implementation of this criterion in design of storm sewers, roadside ditches, detention facilities, open channels and management of overland (sheet) flow, as well as the individual lot, as singular components or as part of a combined system.

PROPERTY OWNER'S RESPONSIBILITY: It shall be the responsibility of each property owner or developer of property whether an individual lot, multiple lots, block or development to design and maintain the drainage of such property without adversely affecting the existing drainage patterns of adjacent property owners or developers, and the City's drainage system. The purpose is to prevent damage by overflow of water onto adjacent landowners caused either by direct diversion of water on the adjoining land or by the failure to adequately accommodate existing drainage patterns.

The attached ***Drainage / Detention Analysis Flow Chart*** provides the outline of the level of drainage and/or detention evaluations necessary for all construction activity within the City. All development with an increase in impervious cover will require preparation of a ***Detention Summary Worksheet*** to determine the need for onsite detention volume, and all development that includes re-grading of the existing natural ground within 20-feett of the property lot line shall require preparation of an ***Impact Analysis***.

This Criteria Manual supplements the City's Drainage Ordinance and applies to all development, both Residential and Non- Residential, as defined in the ordinance. The definitions provided in the City's drainage ordinance shall be the controlling definitions for this Criteria Manual.

Section 2. Drainage Calculations

Runoff Calculations
The rate of storm water runoff (peak discharge) shall be determined for each inlet, pipe, roadside ditch, culvert, outfall, or other designated design point by using the following standards:

1. **Application of Runoff Calculation Models Acceptable Methodology for drainage areas within Bunker Hill** For areas within Bunker Hill, acres served by storm sewer or roadside ditch, peak discharges are based on the Rational Method described below. The on-site drainage storm sewer system shall be sized to convey the 10 year storm event and provide for 100 year sheet flow conveyance.

2. **Application of the Rational Method -** Use of the Rational Method for calculating the peak runoff for a storm drainage system involves applying the following formula to runoff (See Attached *Exhibit 1 - Detention Summary Worksheet* as an exemplar):

   Q = C * I * A

   Where:
   Q = peak discharge (cfs) C = watershed coefficient
   I = rainfall intensity (inches per hour) A = drainage area (acres)
   ** NOTE: Rainfall Intensity based on Chapter 9 of the City of Houston Infrastructure Design Manual*

   Calculation of Runoff Coefficient - The runoff coefficient "C" values in the Rational Method formula varies based on the land use. Acceptable land use types and "C" values are provided as follows:

   Land Use Type Runoff Coefficient
   - Paved Areas and/or Roofs - 0.95
   - Residential Permeable areas:
     - Lots more than ½ acre - 0.35
     - Lots ¼ - ½ acre - 0.45
   - Undeveloped Grass Areas - 0.20

   Composite "C" values for mixed-use drainage areas are allowed for use in the Rational Formula. These values are obtained by calculating a weighted average of all the different "C" values of the sub-areas contributing to each mixed-use drainage area. Any calculations of these Composite "C" values are to be provided as part of the drainage calculations. ***The maximum percent impervious is 45%, with a maximum total lot coverage of 55%.*** [RPL1]

General Design Requirements

A licensed engineer shall provide calculations and designs for all of the components of the storm drainage and detention systems, the peak runoff rate and required storage volume in accordance with these standards for any proposed construction activity. The intent of storm water detention is to mitigate the effect of increased impervious cover, caused by the new construction or reconstruction on an existing structure and/or drainage system (if any). Storm water detention and/or mitigation associated with any proposed construction activity is required as outlined under the following sections and requirements.

As many as three (3) analyses may be required as part of the drainage and detention review for the proposed construction activity:

A. ***Detention Summary Worksheet*** – to document existing and proposed conditions and identify the delta (i.e. change in) impervious cover to define the detention volume and

allowable release rate (10-year event) from the subject property associated with the proposed construction activity.

B. ***Impact Analysis*** – preliminary initial evaluation of adjacent offsite properties to determine if existing sheet flow patterns will be impacted from the proposed construction activity.

C. ***Drainage Study*** – detailed drainage evaluation of onsite improvements and offsite impacts from the proposed construction activity sufficient to develop a mitigation plan to maintain or improve the existing drainage. Coordination with the City and adjacent property owners will be critical to define flow paths, allowable flow rates, and maximum HGL / ponding elevations.

Minimum Pipe sizes

The minimum pipe size for residential on-site conditions (private) shall be 6 inches and for use in any public rights of way shall be 24 inches.

Storm Water Detention Requirements

The design storms for hydrologic routing of detention basins shall be the 10 and 100 year storm events. The required detention shall be as determined for each project based on the 100 year storm event with a 10 year allowable release rate.

For all projects with an increase in impervious cover, the *Detention Summary Worksheet* shall be prepared along with the following information provided:

1. On-site detention shall be required and provided in accordance with the accepted engineers calculations, depending on the specifics of the site.
2. The required detention volume shall be based on the delta of the increased impervious cover.
3. The design discharge from the property into the public storm collection system shall not exceed the existing condition flow rates (Q) for the 10-year design storm as determined in this Standard.
4. The use of runoff hydrographs or routing is not required.
5. No surface detention will be allowed. All required detention will be below ground by use of pipe, vault, or other approved constructed vessels.
6. A single discharge point or connection point to the city's system is required with the calculated release rate applied to the connection piping. Should a single discharge point not be possible, a second discharge point must be approved by the city and the calculated release rate must be applied the cumulative flow of all release points.
7. Adequate inspection ports will be provided to allow for the inspection of the detention facilities for operation and maintenance purposes. Inspection points should be constructed so that entry into the system is not necessary as part of the inspection.

Pumped Facilities

If any pumps are planned for as part of the project early coordination and written agreement by the City shall be required.

Pumped detention systems shall be required to detain 150% of the calculated volume of a gravity system and be required to provide a gravity outfall for ½ the required volume. Full volume shall be required to be drained from an approved vault system within 48 hours of storm event.

Permeable Surfaces

The area of permeable surfaces is required, in square feet, for the calculation of lot coverages and drainage design. In order for an area to qualify as PERMEABLE, the area must be either:

a) The water surface area of a permanently installed swimming pool, ground level fountain, pond or other water containing ground level or below ground level basin which is open to receive rain from directly above the basin, or

b) A permeable system which has been constructed to the standards shown in the attached EXHIBIT 4.

Neither item a nor b may be included as part of any required detention. Any other materials placed on the lot which do not meet the Permeable Surfaces definitions must be included as NON-PERMEABLE surfaces. Grassed and vegetated areas should NOT be included on the lot coverage and drainage calculation details.

Section 3. Requirements for Submittal of Plans, Drawings and Calculations

PRE-DEVELOPMENT MEETING

A pre-development meeting shall be required for any project with increased impervious cover and/or increased building footprint. This meeting shall include a discussion of the drainage analysis requirements of the proposed construction activity and identify the process / path as outlined in the attached *Drainage / Detention Analysis Flow Chart*.

PROCEDURE FOR SUBMISSION OF PLANS - RESIDENTIAL LOT DEVELOPMENT

All plans submitted shall be in the form, and contain fully all information and/or language required, pursuant to this section, including:

1. All engineering and surveying data shall be shown on the plans sufficient to locate all of the features of the plan on the ground. This data shall include, but not be limited to, full dimensions along all boundaries of the plan, street and alley rights-of-way, easements and drainage-ways, gullies, creeks and bayous, together with the location of the high bank of such drainage ways and water courses, storm drainage pipes or systems, lots, blocks, reserves, out tracts or any other tracts designated separately within the plan boundaries, fee strips or any other physical or topographical features necessary to be accurately located by surveying methods. Such information shall include line dimensions, bearings of deflecting angles, radii, central angles and degree

of curvature, length of curves and tangent distances, all of which are to be shown in feet and decimal fractions thereof;

2. The location and approximate width of existing and proposed watercourses, ravines and drainage easements, topographical elevations and the boundaries of designated flood zones, as provided in the then latest edition of the federal insurance rate map. All such information required by this subsection shall be certified by a registered professional land surveyor and/or a registered professional engineer;
3. Contours referred to sea level (U.S. Coast and Geodetic Survey) datum and tied to the latest Federal Emergency Management Agency (FEMA) vertical datum and datum adjustment, as required to show at least two contours within and adjacent to the new construction or reconstruction. If the change in elevation throughout the property to be subdivided is less than one foot, then the plan is to clearly show the outfall drainage plan. Identify the basis of control and temporary benchmark utilized as part of this plan; and
4. All required topographic survey information (see below) collected within ~~40~~ 20-foot buffer on all adjacent property, if required to complete an *Impact Analysis.*

Construction Plan Requirements

1. Existing Contours with 0.5 foot intervals
   a. Tie elevations to latest FEMA vertical datum and datum adjustments
2. Existing Site Plan (including all structures, paved surfaces, walls, fences, drainage features including ditches, swales, pipes, inlets, detention, flow line elevations, FEMA flood plains, etc.)
3. Existing trees
4. Existing drainage (all drainage ditches and pipes {depth, width, diameter, flowline elevations, and material}, inlets, junctions, detention, drainage areas, etc.)
5. Proposed Plans (including all structures, paved surfaces, walls, etc.)
6. Proposed Contours (includes fill) 0.5 foot intervals
   a. Tie elevations to latest FEMA vertical datum and datum adjustments
7. Proposed Trees - identify location of all existing trees to be removed and proposed trees to be planted
8. Adjacent Property within 20 feet
9. Proposed drainage plan, including all structures, surface and underground drainage, inlets, detention, pump system, low impact development information and any other features that could impact drainage.
   a. Clearly define outfall point of connection to existing public stormwater collection system.
10. Stormwater drainage calculations for proposed conditions, including detention worksheet (increased impervious cover, required volume, and allowable release rate)

Drainage Area Map

A drainage area map and supporting data sheets shall be included with the construction plans or in a separate drainage study. The drainage area map shall include:

1. Drainage areas, including off-site areas that drain to the project area or are downstream that the project area drains across prior to an outfall point of connection to existing public stormwater collection system.
2. Design storm runoff. The design storm event to use is the 10-year event for storm sewer outfall and conveyance as well as the 100-year for sheet flows. All lot flow should be directed to onsite collection system prior to outfall into a City system, with an outfall sized based on 10-year existing flow rate.
   a. Route of overland flow including the overflow to a drainage way sized to accommodate the 100-year flow (see Sheet Flow analysis).
3. Elevations for the 10-year and 100-year storms in the receiving system.
4. Design discharge per inlet.
5. Maximum 10-year and 100-year ponding elevation at each inlet.

Other Requirements

Detailed drainage calculations shall be submitted with the construction plans.

The 10- and 100-year Hydraulic Grade Line (HGL) for the design storm shall be shown on the

construction drawings. Calculations for the elevation of the HGL shall be provided with the design storm drainage calculations. The 10-year HGL shall be at or below natural ground.

PROCEDURE FOR SUBMISSION OF PLANS - SUBDIVISION DEVELOPMENT

See the City's Drainage Ordinance and Subdivision Ordinance for additional drainage requirements for replatting or new subdivisions development.

Property owner(s) shall be responsible for preparing and submitting an *Impact Analysis* and *Drainage Study* for the overall system and shall be required to provide detention volume to fully detain 100% of the stormwater runoff from the development, including any proposed public street.

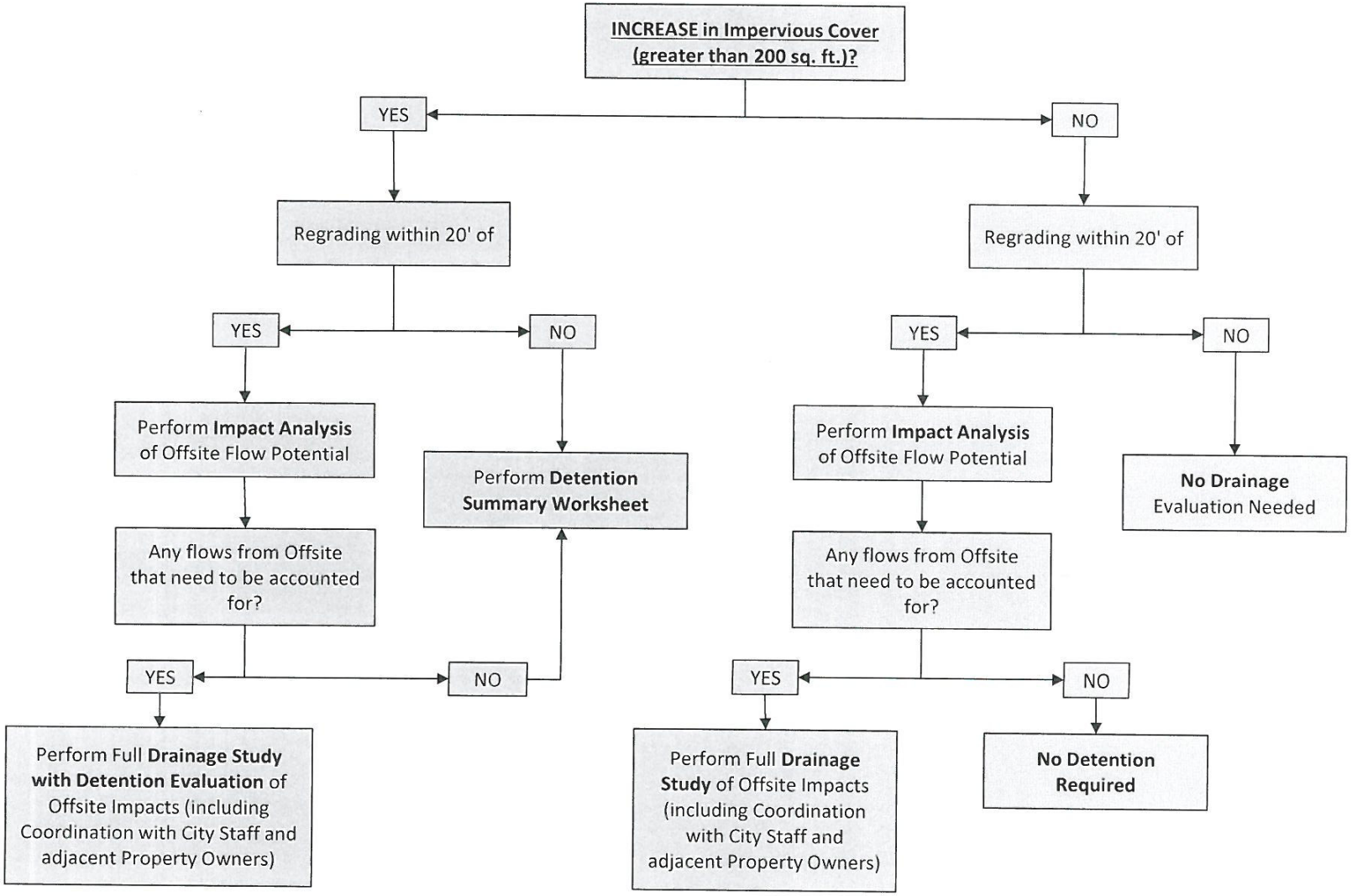
Detailed evaluation of all offsite property within a 60-foot radius of proposed development shall be required along with individual drainage plans for each lot to be submitted to the City for review and approval. Notification of all property owners within a 200-foot radius of proposed development shall be required as will copies of the *Impact Analysis* and *Drainage Study* to be provided to adjacent property owners.

PROCEDURE FOR SUBMISSION OF PLANS - COMMERCIAL DEVELOPMENT (Non-Residential)

See the City's Drainage Ordinance and Special Use Permit process for additional drainage requirements for commercial / non-residential development.

EXHIBIT 1

Drainage / Detention Analysis Flow Chart



NOTE: ***"Perform"*** *includes preparation of said analysis, submittal to City's Director of Public Works, incorporation of review comments, and resubmittal as final report for approval / concurrence. Completion of said analysis is required prior to permitting.*

10/16/14

EXHIBIT 2

Detention Volume Worksheet

ADDRESS: Example Street

	Sq Ft	Acres
Lot Size:	25,000	0.574

	ENTER EXISTING CONDITIONS IN RED AREAS			ENTER PROPOSED CONDITIONS IN BLUE AREAS			
	Existing (Pre-Construction)			Proposed (Post-Construction)			
Non-Permeable Lot Coverage (SF) [1]	*2,500*	*10%*	*0.057*	2,500	*10%*	*0.057*	
Non-Permeable to be REMOVED (SF)	-	*0%*	-	*2,500*	*10%*	0.057	Removed
Non-Permeable to be ADDED (SF)	-	*0%*	-	*11,250*	*45%*	0.258	Added
Net Non-Permeable Lot Coverage (SF)	**2,500**	**10%**	**0.057**	**11,250**	**45%**	**0.258**	
Permeable Lot Coverage (SF) [2]	*500*	*2%*	*0.011*	500	*2%*	*0.011*	
Permeable to be REMOVED (SF)	-	*0%*	-	-	*0%*	-	Removed
Permeable to be ADDED (SF)	-	*0%*	-	*2,000*	*8%*	0.046	Added
Net Permeable Lot Coverage (SF)	**500**	**2%**	**0.011**	**2,500**	**10%**	**0.057**	
Total Non-Permeable & Permeable Lot Coverage (SF)	**3,000**	**12%**	**0.069**	**13,750**	**55%**	**0.316**	

	TC	C (Non-Perm)	C (Perm)	C (Grass)
Time of Concentration = $10A^{0.1761}+15$	24.07	0.9	0.35	0.20

Non-Perm Increase	Non-Perm Coverage	Total Lot Coverage
35%	45%	55%

$I=b/(d+TC)^e$

	b	d	e	I
10-Year Rain Event	93.53	18.90	0.7742	5.09
100-Year Rain Event	125.40	21.80	0.7500	7.11

	EXISTING (PRE-CONSTRUCTION)			PROPOSED (POST-CONSTRUCTION)		
	Comp "C"	Total CFS	GPM	Comp "C"	Total CFS	GPM
10-Year Rain Event	0.27	0.80	358	0.53	1.55	695
100-Year Rain Event		1.11	500		2.16	971

Lot Size:	0.574 *Acres*
Non-Perm Coverage:	45%
Non-Perm Increase:	35%
Total Vol Required:	0.139 *Ac-Ft*
Total Vol Required:	45,314 *gallons*
Max Release Rate [3]:	0.80 *cfs*

NOTES:

*1. Non-Permeable Coverage includes Foundations and/or Roofs, Walkways, Driveways, Pool Decking and Coping, Gravel Areas, Decks

*2. Permeable Coverage includes Pool Water Surface Area, Permeable Driveways, Permeable Walkways. DO NOT INCLUDE GRASSED AND BED AREAS.

*3. Max allowable release is based on Existing (Pre-Construction) 10-yr flow.

*4. See City specifications for permeable surfaces to determine if an area may be included as permeable.

*5 All detention must be below ground level.

10/16/14

Exhibit 3 - CITY OF BUNKER HILL VILLAGE -
Detention Rate Summary (Ac-Ft / Ac)

% Incr - Non-Perm	Under 1/2 Acre
0%	-
5%	0.0300
10%	0.0590
15%	0.0890
20%	0.1185
25%	0.1480
30%	0.1775
35%	0.2070
40%	0.2365
45%	0.2660

% Incr - Non-Perm	Over 1/2 Acre
0%	-
5%	0.0345
10%	0.0690
15%	0.1040
20%	0.1385
25%	0.1730
30%	0.2075
35%	0.2425
40%	0.2770
45%	0.3115

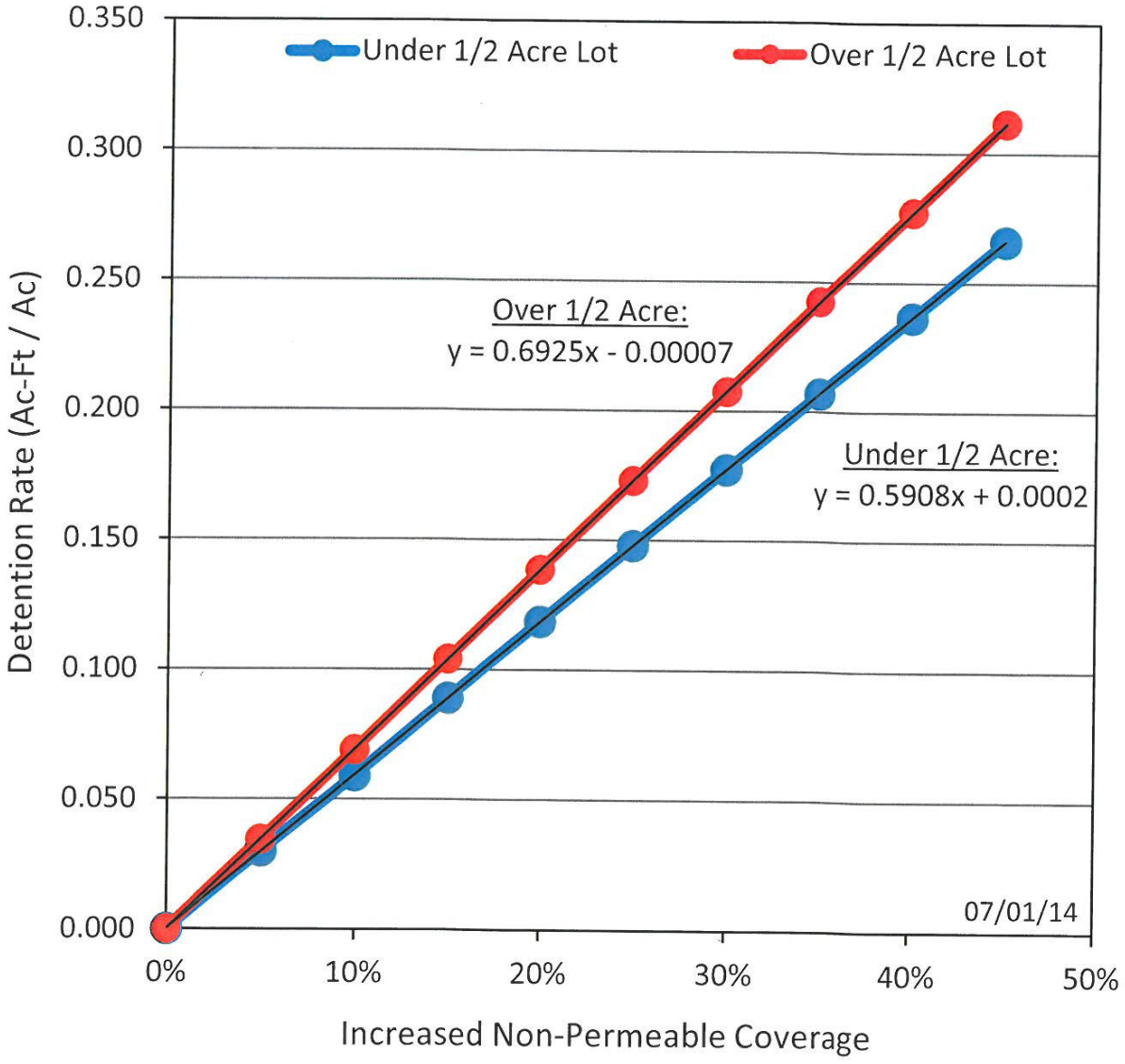
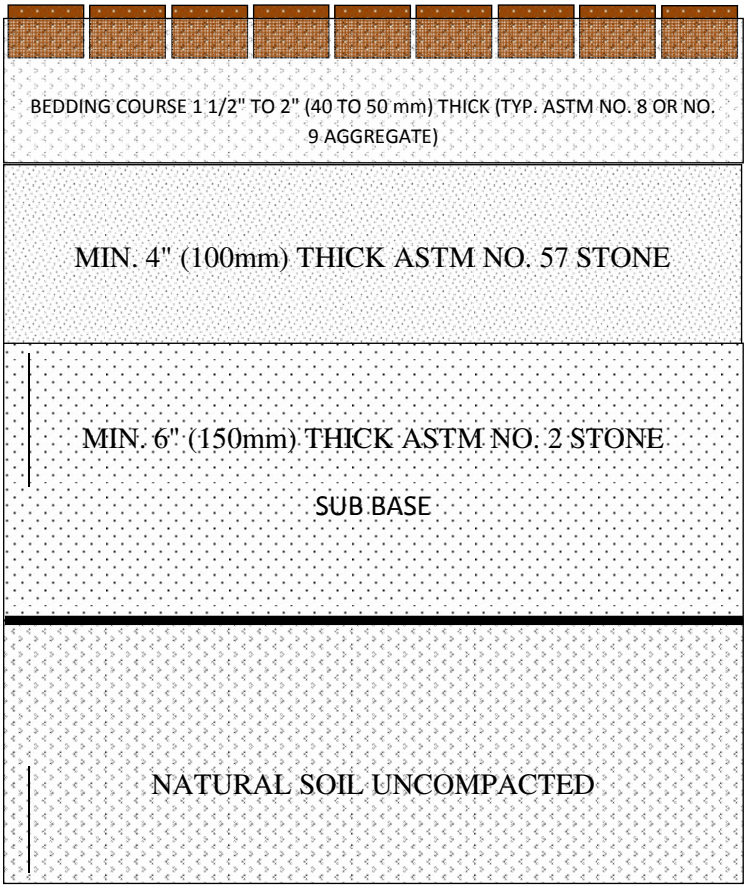


EXHIBIT 4

PERMEABLE SYSTEMS

PERMEABLE PAVERS MIN. 3 1/8" (80 mm) THICK



Permeable pavers and other permeable surfaces are allowed as hardscapes but still count towards the maximum total lot coverage.

Any system which requires compacting or results in the subsoil becoming compacted will not be approved. Gravel and other aggregates spread on the ground surface will result in soil compaction over time and therefore do not qualify as permeable materials.

Pavers must be engineered as a permeable product and installed as to allow all of the underlying soil to absorb water at the same rate as surrounding native soil. Flagstone and other large coverage materials do not meet this requirement.

Permeable pavement areas must meet the same setbacks and location restrictions as non-permeable surfaces.

Please see driveway design standards for required roadway connection requirements.

Permeable concrete may be used in the same configuration as a paver, but similar bedding, base and sub-base materials will be required to allow adequate soil absorption.

Sand materials are not allowed in any stage of a permeable system.

The drawing shown represents minimum design specifications. Please see your specific manufacturer for additional requirements.