Note: "Section" Items in red specify sections in the proposed Stormwater Management and Design Criteria Manual

Exhibit E

Article 410-VII Stormwater Management For Public And Private Improvements

410.650 General Provisions
410.660 Stormwater Planning And Design
410.670 Stormwater Runoff Calculations
410.680 Stormwater Drainage Structures
410.690 Stormwater Detention Design
410.700 Sinkholes And Karst Features
410.710 Grading, Sediment And Erosion Control

410.650 General Provisions

Section 1.1 A. *Scope.* These design criteria set forth the minimum standards for design of storm drainage facilities on public right-of-way and private property in the City of Republic.

Section 1.2 B. *Authority.*

1. These design criteria and standards set forth herein have been adopted by the Planning and Zoning Commission and the City Council *in accordance with the procedures and authority set forth in the City of Republic*.
2. Any development or grading begun after the date of passage of these criteria and standards which does not comply with the requirements set forth herein shall be deemed to be in violation of the requirements established herein; and shall be subject to enforcement measures and penalties set forth in Section **100.220** — General Penalty.

Section 1.3 C. *Interpretations.*

1. Where any of the provisions contained herein may be unclear or ambiguous as they pertain to a particular site or situation, interpretations of the policies, criteria and standards set forth herein shall be made in writing by the Community Development Director.
2. Such written interpretations shall be kept on file for future reference for use in similar situations and shall be incorporated in subsequent revisions for the standards, if deemed necessary for general reference.

Section 1.4 D. *Appeals.*

1. Where disagreements may arise over the interpretation of the requirements set forth herein, appeals may be made to the City Planner upon written request.
2. Information and supporting documentation for the appeal shall be submitted with the request. The City Planner shall forward the information to the Public Works Director, Community Development Director or the City Engineer within three (3) calendar days following receipt of the information.

Section 1.5 E. *Approvals And Permits Required*.

Section 1.5.1 1. *Grading permit*. Storm drainage facilities may not be constructed or altered without review and approval of the plans by the City and issuance of a Grading Permit by the City for subdivisions or for commercial or other sites.

Section 1.5.2 2. *National Pollutant Discharge Elimination System (NPDES) stormwater permit*.

a. Provisions of the 1987 Clean Water Act require that certain stormwater discharges obtain an NPDES stormwater permit. In Missouri, these permits are

Section 1.5.2.1 - Added section for Missouri Land Disturbance Permit administered by the Missouri Department of Natural Resources.

Section 1.5.2 b. Federal rules for NPDES stormwater discharges are contained in 40 CFR Parts 122, 123 and 124 of the Code of Federal Regulations. State NPDES stormwater regulations are contained in 10 CSR 20-6.200 of the Code of State Regulations. Additional provisions for NPDES stormwater permits for land disturbance activities and information regarding the City of Republic General Permit for land disturbance activities are contained in Section **410.710** of these Criteria.

Section 1.5.3 c. *"404" Permit*.

(1) For certain activities, which involve the discharge of dredged or fill materials into the waters of the United States a Department of the Army permit may be required as set forth Section 404 of the Clean Water Act. Rules for 404 permits are contained in 33 CFR Parts 320 through 330 of the Code of Federal Regulations.

(2) Determination of applicability for Section 404 requirements are generally made by the Kansas City or Little Rock District office of the Corps of Engineers.

(3) A brochure regarding the Corps of Engineers regulatory program may be obtained from the Corps offices.

Section 1.6 F. *Coordination With Other Jurisdictions*.

Section 1.6.1 1. Where proposed storm drainage facilities are located on property adjoining to other local government jurisdictions design of storm drainage facilities shall include provisions to receive or discharge storm water in accordance with the requirements of the adjoining jurisdiction, in addition to meeting City requirements.

Section 1.6.2 2. In these cases two (2) additional sets of plans shall be submitted and will be forwarded to the adjoining jurisdiction for review and comment.

Section 1.6.3 3. No grading or construction of storm drainage facilities may commence without prior notification of the Missouri One Call utility warning system at 1-800-DIG-RITE, as required by law.

Section 1.7 G. *Communications And Correspondence*. Communications and correspondence regarding stormwater plan review, policies, design standards, criteria or drainage complaints shall be directed to the City Planner at the City of Republic, 213 N. Main, Republic, Missouri 65738, Phone: 417-732-3354.

Section 1.8 H. *Ownership And Maintenance*.

Section 1.8.1 1. *Improvements on public road right-of-way*. Storm drainage improvements on public right-of-way shall, upon acceptance of the constructed improvements, become the property of; and shall be maintained by the City of Republic.

Section 1.8.2 2. *Improvements on private property*.

Section 1.8.2.1 a. Storm drainage improvements on private property shall be maintained by the owner of the lot upon which the improvements are located or by the Homeowners' Association for improvements located in common areas.

Section 1.8.2.2 b. All such improvements, which serve a drainage area, shall be located in drainage easement and the public shall have such rights of access to repair or maintain such facilities as set forth in Section **410.680(E)(4)**.

[Ord. No. 02-47 §§1 — 2, 11-25-2002]

Section 2

410.660 Stormwater Planning And Design

Section 2.1 A. *Stormwater Management Goals*. In order to ensure protection of the general health and welfare of the citizens of the City of Republic, planning and design of stormwater management measures shall meet the following goals:

1. Prevent damage to residential dwellings and other building structures from floodwaters.
2. Maintain emergency vehicle access to all areas during periods of high water.
3. Prevent damage to roads, bridges, utilities and other valuable components of the community's infrastructure from damage due to flood waters and erosion.
4. Prevent degradation of surface and groundwater quality from storm water runoff; preserve and protect quality of the environment; and promote conservation of the City's natural resources.
5. Minimize floodwater and erosion damage to lawns, recreational facilities and other outdoors improvements.
6. Minimize traffic hazards from runoff carried in streets and roads.
7. Comply with applicable State and Federal laws and regulations.
8. Meet the foregoing goals in a manner which is cost effective and which minimizes the cost of housing and development while encouraging sound development practices.
9. Encourage innovative and cost effective planning and design of stormwater management facilities.
10. Encourage multiple purpose design of stormwater management facilities, to provide opportunities for recreational use and other benefits to the community wherever possible.

The standards and criteria set forth herein provide the minimum standards for planning and design of stormwater facilities. Where a particular plan or design may be found to be in conflict with a specific standard, achievement of the goals set forth above will have precedence.

B. ~~*General Planning And Design Principles*~~.

Removed

1. ~~The City of Republic recognizes that stormwater management is an important component of overall land use planning.~~
2. ~~The City of Republic further recognizes that proper stormwater planning significantly reduces the long-term costs to the community both in terms of infrastructure cost and property losses due to flood damage. It is much more cost effective to prevent flood damage by proper design and construction, than to repair and remediate problems, which have occurred through poor planning and design.~~
3. ~~The following general principles must be followed in preparing the grading and storm drainage plans for all development sites:~~
   a. ~~*Recognize the existing drainage system*. The storm drainage system differs from other utility systems in very important ways:~~
      ~~(1) There is an existing natural drainage system.~~
      ~~(2) It is only needed when runoff occurs.~~

Removed.

(3) The capacity of the system varies greatly depending upon how much it rains.

(4) The system does not have to be constructed of man-made components in order to function.

b. Because of these characteristics there has been a historic inclination for fragmented planning and design of storm drainage facilities.

c. Proper planning of storm drainage facilities must begin with the recognition of the existing system, and include necessary provisions for preserving or altering the existing system to meet the needs of proposed development or construction.

d. Methods of delineating existing watercourses are outlined in Section **410.670**.

4. *Allow for increase in runoff rates due to future urbanization*.

a. As areas urbanize, peak rates of runoff increase significantly. The City of Republic may require temporary detention and storage of increased volumes of urban runoff in order to minimize increases in flow rates as urbanization occurs. However, the cumulative effects of on-site detention are difficult to predict and control and development of comprehensive basin-wide runoff models to determine these effects does not appear likely in the foreseeable future.

b. For this reason, design of storm drainage improvements must be based upon the assumption of fully urbanized conditions in the area under consideration. No reduction in peak flow rates due to detention, unless an approved runoff model has been developed for the drainage basin under consideration. Any detention storage facilities whose effects are considered must be located within approved drainage easements.

5. *Provide for acceptance of runoff from upstream drainage areas*.

a. It is critical that provisions be made to receive runoff from upstream drainage areas. Drainage easements or public right of way must extend to a point where the upstream drainage area is no greater than five (5) acres.

b. Drainage easements or public right-of-way must extend to the point where existing watercourses enter the site. Where the upstream drainage area is five (5) acres or greater, but does not discharge onto the site through a defined watercourse, the drainage easement shall extend to the point of lowest elevation.

6. *Provide a means to convey runoff across the site*. Stormwater shall be conveyed across the site in a system of overland drainage ways and storm sewers. Overland drainage ways consists of streets, open channels, swales and overland flow within drainage easements.

7. *Discharge of runoff to downstream properties*.

a. Concentrated runoff shall be discharged only into existing watercourses, drainage easements or public road rights-of-way. Where none of these exist, a drainage easement which extends to the nearest watercourse, drainage easement or public road right-of-way must be obtained from the downstream property owner and proper provisions made for conveyance of the peak flow from the one percent (1%) annual probability (100-year) storm within the drainage easement.

b. One of the typical results of urbanization is that diffuse surface flow or "sheet flow" is replaced with concentrated points of discharge. Where concentrated flows are discharged to downstream properties proper provisions must be made to:

(1) Allow the flow to spread over the same area as would have occurred for the same rate of flow prior to the development, and

Removed.

(2) Reduce the rate of velocity to rates at least equal to the pre-development values at the same rate of flow.

8. *Assess potential downstream flooding problems*.

a. It is important that a determination be made of conditions in the watershed downstream of each development site. Specifically it is important to determine whether there are existing structures, which are subject to an unacceptable flooding hazard.

b. If areas having an unacceptable flooding hazard occur downstream of a development site, either on-site detention for peak flow control or mutually agreed off-site improvements will be required, as set forth in Section **410.680**.

9. *Assess potential water quality impacts on receiving waters*. Sediment, erosion and other water quality controls are required as set forth in Section **410.700** and Section **410.710**.

Section 1.8.2.2

C. *Drainage Easements*. All areas subject to inundation during the major storm must be included in drainage easements. Specific standards for drainage easements to be provided for storm sewers, open channels and detention facilities are set forth in Section **410.680**.

[Ord. No. 02-47 §§1 — 2, 11-25-2002]

410.670 Stormwater Runoff Calculations

A. This Section outlines acceptable methods of determining stormwater runoff.

1. *General guidelines*.

Removed.

a. For watersheds with a total tributary area less than two hundred (200) acres and a one percent (1%) annual probability (100 year) fully developed discharge less than three hundred (300) cfs, the design storm runoff may be analyzed using the rational formula.

b. For watersheds with a total tributary area greater than two hundred (200) acres or with a one percent (1%) annual probability (100-year) fully developed discharge greater than three hundred (300) cfs, the design storm runoff shall be analyzed using an approved hydrograph method.

Section 3.3

2. *Rational formula*.

Section 3.3.2

a. The rational formula, when properly understood and applied, can produce satisfactory results for urban storm sewer design. The rational formula is as follows:

$Q = CIA$

Where:

Q = Peak discharge in cubic feet per second.
C = Runoff coefficient which is the ratio of the maximum rate of runoff from the area to the average rate of rainfall intensity for the time of concentration.
I = Average rainfall intensity in inches per hour for a duration equal to the time of concentration.
A = Contributing watershed area in acres.

Section 3.3.3 b. The basic assumptions made when applying the rational formula are:

(1) The rainfall intensity is uniform over the basin during the entire storm duration.

(2) The maximum runoff rate occurs when the rainfall lasts as long or longer than the basin time of concentration.

(3) Runoff response characteristics are relatively uniform over the entire basin.

(4) The time of concentration is the time required for the runoff from the most hydraulically remote part of the basin to reach the point of interest.

c. The drainage basin should be divided into sub-basins of a size where all of the basic assumptions apply.

Section 3.6 3. *Time of concentration*.

Section 3.6.1 a. Time of concentration, etc., is calculated by:

tc = ti + tt (5 minutes, minimum);where
ti = initial, inlet or overland flow time in minutes,
tt = shallow channel and open channel flow time in minutes.

b. Overland flow (sheet flow) time shall be calculated as:

$ti = (n \times L)^{0.8}/(4.64 \times S^{0.4})$ where
ti = initial, inlet or overland flow time in minutes,
n = Manning's n for sheet flow (from the following table),
L = Overland flow length in feet, (maximum of three hundred (300) feet),
S = Slope in feet per foot.

Table 3-7 **ROUGHNESS COEFFICIENTS (Manning's n) FOR SHEET FLOW SURFACE DESCRIPTION**

Smooth surfaces (concrete, asphalt, gravel or bare soil)	0.011
Fallow (no residue)	0.050
Cultivated soils:	
Residue cover less than or equal to 20%	0.060
Residue cover greater than or equal to 20%	0.170
Grass:	
Short grass prairie	0.150
Dense grasses[1]	0.240

Bermuda grass	0.410
Range (natural)	0.130
Woods:[2]	
Light underbrush	0.400
Dense underbrush	0.800

NOTES:
1 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass and native grass mixtures.

2 When selecting n, consider cover to a height of about 0.1 feet. This is the only part of the plant cover that will obstruct sheet flow.

Shallow channel velocities may be estimated from Figure 3-1 in reference 11.

Open channel flow velocities may be estimated from Manning's equation. Open channel velocities are generally estimated under bank full conditions.

The basin time of concentration calculation techniques are described in detail in TR-55, Chapter 3 (reference 11).

Section 3.4 4. *Hydrograph methods*.

a. *Methodologies*.

(1) The most common hydrograph techniques are those developed by the Corps of Engineers and the Soil Conservation Service. These methods are preferred, however other proven techniques will be accepted.

(2) The Corps of Engineers HEC-1 Flood Hydrograph Package and Soil Conservation Service TR-55 computer models are the preferred runoff models. Other models may be used with approval from the City.

(3) The runoff model must include the entire drainage basin upstream of the proposed development. The model shall be prepared in sufficient detail to ensure that peak runoff rates are reasonably accurate.

Section 2.2 (4) The runoff model shall be developed for the following cases:

Section 2.2.1 (A) Case 1: Existing conditions in the drainage basin prior to development of the applicant's property.

Section 2.2.2 (B) Case 2: Existing conditions in the drainage basin with developed conditions on the applicant's property.

Section 2.2.3 (C) Case 3: Fully developed conditions in the entire drainage basin.

Section 3.4.3 b. *Rainfall.*

Section 3.4.3.1 - Table 3-2 (1) Rainfall depth-duration-frequency and intensity-duration-frequency curves for the Republic area are included in the standard drawings. The design rainfall intensities were developed from the U.S. Department of Commerce, National Weather Service, Technical Paper 40 (reference 19) and the National Oceanic and Atmospheric Administration publication "HYDRO-35" (reference 9).

(2) Rainfall depths for use with hydrograph techniques shall be taken from "Rainfall Frequency atlas of the Midwest, Bulletin 71" (reference 23).

Section 3.4.3.2

(3) Rainfall shall be distributed in time using Huffs Distribution or the Pilgrim-Cordery Distribution adapted to local rainfall data (references 20 and 21) as shown in the following table. Other distributions may be used upon approval from the City.

Pilgrim-Cordery Method Synthetic Rainfall Mass Curves

Cumulative Fraction of Depth	Cumulative Fraction of Storm Duration				
	1-Hour	2-Hour	3-Hour	4-Hour	6-Hour
.00	.00	.00	.00	.00	.00
.05	.03	.03	.03	.02	.05
.10	.07	.05	.05	.03	.09
.15	.11	.10	.06	.05	.14
.20	.14	.17	.09	.06	.20
.25	.17	.22	.11	.08	.28
.30	.23	.25	.13	.14	.35
.35	.29	.27	.19	.20	.41
.40	.35	.29	.31	.27	.43
.45	.41	.30	.39	.33	.46
.50	.47	.31	.44	.38	.49
.55	.56	.41	.47	.47	.60
.60	.65	.51	.54	.56	.70
.65	.73	.60	.64	.64	.80
.70	.82	.69	.70	.74	.86
.75	.91	.78	.73	.83	.89
.80	.93	.82	.81	.87	.93
.85	.95	.87	.89	.90	.96
.90	.97	.92	.94	.93	.97
.95	.99	.96	.98	.97	.98
1.00	1.00	1.00	1.00	1.00	1.00

[Ord. No. 02-47 §§1 — 2, 11-25-2002]

410.680 Stormwater Drainage Structures

Section 4.2 A. *Inlets*.

Section 4.2.1 1. *Inlet locations*. Inlets shall be provided at locations and intervals and shall have a minimum inflow capacity such that maximum flooding depths set below are not exceeded for the specified storm; at all sump locations where ponding of water is not desired and where drainage cannot be released at the ground surface.

Section 4.2.2 2. *Inlet interception capacities*.

a. Inlet capacities shall be determined in accordance with the Federal Highway Administration HEC-12 Manual (reference 5).

b. Nomographs and methods presented in the Neenah Inlet Grate Capacities report (reference 12) may also be used where applicable.

c. The use of commercial software utilizing the methods of HEC-12 is acceptable. It is recommended that software be pre-approved for use by the City.

Section 4.2.3 3. *Clogging factors.* The inlet capacities determined as required in this Section must be reduced as follows, in order to account for partial blockage of the inlet with debris:

Inlet Type And Location	Clogging Factor
Type SS Curb Opening Inlets:	
on grades	0.9
in sumps	0.8
Grated Inlets:	
on grades	0.6
in sumps	0.5

Inlet lengths or areas shall be increased as required to account for clogging.

Section 4.2.4 4. *Interception and bypass flow*. It is generally not practical for inlets on slopes to intercept one hundred percent (100%) of the flow in gutters. Inlets must intercept sufficient flow to comply with street flooding depth requirements. Bypass flows shall be considered at each downstream inlet, until all flow has entered approved storm sewers or drainage ways.

Section 4.3 5. *Allowable street depths*. Urban streets are a necessary part of the City drainage system. The design for the collection and conveyance of storm water runoff is based on a reasonable frequency and degree of traffic interference. Depending on the street classification, (i.e. local, collector, etc.) portions of the street may be inundated during storm events. Drainage of streets are controlled by both minor and major storm events. The minor system is provided to intercept and convey nuisance flow. Flow depths are limited for the major storm to provide for access by emergency vehicles during most flood events. When the depths of flow exceed the criteria presented in this Section a storm sewer or open channel system is required.

a. *General design guidelines*.

Section 4.3.1 (1) *Allowable flow depths:* Flow in the street is permitted with allowable depths of flow as follows:

Section 4.3.2 (2) *Local streets:* Crown of the street for the runoff from a 5-year rainfall, top of curb for runoff from a 25-year rainfall. Runoff from a 100-year rainfall should be contained within the right-of-way.

Section 4.3.3 (3) *Collector streets:* The equivalent of one (1) ten (10) foot driving lane must remain clear of water during a 5-year rainfall, top of curb for runoff from a 25-year rainfall. Runoff from a 100-year rainfall should be contained within the right-of-way.

Section 4.3.4 (4) *Arterials and parkways:* Two (2) ten (10) foot lanes must remain clear of water, one (1) in each direction, during a 5-year rainfall. Top of curb for runoff from a 25-year rainfall. Runoff from a 100-year rainfall should be contained within the right-of-way.

Where allowable depths are exceeded a storm sewer system must remove the excess water.

(5) *Arterials and parkways:* Two (2) ten (10) foot lanes must remain clear of water, one (1) in each direction for the 25-year storm. For the 100-year storm, a maximum of six (6) inches at the crown, depth at the gutter shall not exceed eighteen (18) inches.

Where allowable depths are exceeded a storm sewer system must remove the excess water.

Section 4.3.5 b. *Cross flow*. Cross flow at intersections is permitted up to the following depth.

Street Classification	**5-year Storm**	**25-year Storm**
	Allowable Depth	**Allowable Depth**
Local	6" in cross pan flow line	12" at gutter
Collector	No cross flow permitted	6" at gutter
Arterial or Parkway	No cross flow permitted	No cross flow permitted

Section 4.3.6 c. *Hydraulics*. The allowable storm capacity of each street section with curb and gutter is calculated using the modified Manning's formula for both the 2-year and 25-year storm event.

	$Q = 0.56(Z/n)S^{1/2}d^{8/3}$
Where,	Q = discharge in cubic feet per second
	Z = cross slope of the street in feet per foot
	d = depth of flow at the gutter in feet
	S = longitudinal slope of the street in feet per foot
	n = Manning's roughness coefficient

Section 4.2.5 6. *Types of inlets allowed*.

Section 4.2.5.1 a. *Public streets*.

Section 4.2.5.1.1 (1) *Curb opening inlets*. Type "SS" standard curb opening inlets as shown Drawing 140 shall be used for public streets with curb and gutter.

Section 4.2.5.1.2 (2) *Graded inlets*.

In general the use of grated inlets in streets, which require adjustment when streets are repaved will not be permitted.

Where conditions are such that curb inlets cannot intercept the required rate of flow, necessary to control street flooding depth or to provide diversion of flow to detention, sedimentation or infiltration basins, "trench inlets" with veined grates may be specified with approval of the City.

Other types of inlets will not be permitted unless approved by the City.

Section 4.2.5.2 b. *Outside of public right-of-way*. The type of inlets specified outside of public right-of-way is left to the discretion of the designer provided the following criteria are met:

(1) Maximum flooding depths for the major or minor storm as set forth above are not exceeded.

(2) General safety requirements set forth below are met.

(3) All inlets shall be depressed a minimum of two (2) inches below the surrounding grade to allow proper drainage to the inlet and prevent inadvertent ponding in the area around the inlet.

(4) Inlets in pavements shall be provided with a concrete apron.

Section 4.2.6 7. *General safety requirements*. All inlet openings shall:

a. Provide for the safety of the public from being swept into the storm drainage system; the maximum allowable opening shall not exceed six (6) inches in width.

b. Be sufficiently small to prevent entry of debris which would clog the storm drainage system;

c. Be sized and oriented to provide for safety of pedestrians, bicyclists, etc.

Section 4.1

B. *Storm Sewers*.

1. *Design criteria*.

a. *Design storm frequency*. The storm sewer system, beginning at the upstream end with inlets, is required when the 5-year peak flow in the street exceeds five (5) cfs or when allowable street depths are exceeded. Allowable street depths are specified above.

b. *Construction materials*. Storm sewers may be constructed using reinforced concrete, corrugated metal (steel or aluminum) or plastic pipe. The materials, pipes or appurtenances shall meet one (1) or more of the following standards:

PIPE MATERIAL	STANDARD

Reinforced Concrete Pipe — Round	ASTM C-76 or AASHTO M-170
Reinforced Concrete Pipe — Elliptical	ASTM C-507 or AASHTO M-207
Reinforced Concrete Pipe — Joints	ASTM C-443 or AASHTO M-198
Reinforced Concrete Pipe — Arch	ASTM C-506 or AASHTO M-206
Pre-cast Concrete Manholes	ASTM C-478 or AASHTO M-199
Pre-cast Concrete Box Pipe	ASTM C-789/C-850 or AASHTO M-259/M-273
Corrugated Steel Pipe-Metallic Coated for Sewers and Drains	AASHTO M-36
Corrugated Aluminum Alloy Pipe and Under Drains	AASHTO M-196
Bituminous Coated Corrugated Metal Pipe and Pipe Arches	AASHTO M-190
Corrugated PVC Pipe	ASTM D-3034 and ASTM F-679
Corrugated Polyethylene Pipe	ASTM D-1248

Section 4.1.7 c. *Vertical alignment*.

Section 4.1.7.1 (1) The sewer grade shall be such that a minimum cover is maintained to withstand AASHTO HS-20 loading on the pipe. The minimum cover depends upon the pipe size, type and class and soil bedding condition, but shall not be less than one (1) foot from the top of pipe to the finished grade at any point along the pipe. If the pipe encroaches on the street subgrade, approval is required. Manholes will be required whenever there is a change in size, direction, elevation grade and slope or where there is a junction of two (2) or more sewers. The maximum spacing between manholes for storm sewers (cross sectional area less than twenty-five (25) square feet) shall be four hundred (400) feet. For large storm sewers (cross sectional area greater than twenty-five (25) square feet), manholes for maintenance access need only be placed a minimum of every five hundred (500) feet; access to the laterals can be obtained from within the larger storm sewer.

Section 4.1.7.5 (2) The minimum clearance between storm sewer and water main (for new construction), either above or below shall be twelve (12) inches. Concrete encasement of the water line will be required for clearances of twelve (12) inches or less when the clearance between existing water mains cannot be obtained.

Section 4.1.7.6 (3) The minimum clearance between storm sewer and sanitary sewer (for new construction), either above or below, shall be eighteen (18) inches. In addition, when an existing sanitary sewer main lies above a storm sewer or within eighteen (18) inches below, the sanitary sewer shall have an impervious encasement or be constructed of structural sewer pipe for a minimum of ten (10) feet on each side of the storm sewer crossing.

Section 4.1.7.7 (4) Siphons or inverted siphons are not allowed in the storm sewer system.

Section 4.1.8 d. *Horizontal alignment*.

Section 4.1.8

(1) Storm sewer alignment between manholes shall be straight except when approved by the City. Approved curvilinear storm sewers may be constructed by using radius pipe. The radius requirement for pipe bends is dependent upon the manufacturer's specifications.

(2) A minimum horizontal clearance of ten (10) feet is required between sanitary and water utilities and the storm sewer.

(3) The permitted locations for storm sewer within a street ROW are: (a) on centerline, (b) between centerline and curb and (c) behind the curb. Storm sewer shall not be placed on the area within the wheel lanes of the pavement.

Section 4.1.5

e. *Pipe size*. The minimum allowable pipe size for storm sewers is dependent upon a diameter practical from the maintenance standpoint. For storm sewers less than fifty (50) feet in length the minimum allowable diameter is fifteen (15) inches. All other pipe shall have a minimum diameter of eighteen (18) inches.

Section 4.1.5

f. *Storm sewer capacity and velocity*.

(1) Storm sewers should be designed to convey the design storm (25-year) flood peaks without surcharging the storm sewer. The sewer may be surcharged during larger floods and under special conditions when approved by the City.

(2) The capacity and velocity shall be based on the Manning's n-values presented in Table I. The maximum full flow velocity shall be less than fifteen (15) fps. Higher velocities may be approved by the City if the design includes adequate provisions for uplift forces, dynamic impact forces and abrasion. The minimum velocity in a pipe based on full flow shall be two and one-half (2.5) fps and the minimum slope shall be one-half percent (0.50%) to avoid excessive accumulations of sediment. The energy grade line (EGL) for the design flow shall be no more than six (6) inches below the final grade at manholes, inlets or other junctions. To insure that this objective is achieved, the hydraulic grade line (HGL) and the energy grade line (EGL) shall be calculated by accounting for pipe friction losses and pipe form losses. Total hydraulic losses will include friction, expansion, contraction, bend, manhole and junction losses. The methods for estimating these losses are presented in the following Sections.

Section 4.1.9

g. *Storm sewer outlets.* All storm sewer outlets into open channels shall be constructed with a headwall and wingwalls or a flared-end-section. Riprap or other approved material shall be provided all outlets.

Section 4.1.10

h. *Hydraulic evaluation*. Presented in this Section are the general procedures for hydraulic design and evaluation of storm sewers. The user is assumed to possess a basic working knowledge of storm sewer hydraulics and is encouraged to review textbooks and other technical literature available on the subject.

Section 4.1.10.4.1

i. *Pipe friction losses*. Pipe friction losses are estimated using Equation 1001 and Manning's formula (Equation 1002) which are expressed as follows:

	Hf = Sf x L	(1001)

Where,	Hf = head loss due to friction (feet)	
	Sf = friction slope from Manning's equation (feet per foot)	
	L = length of pipe segment (feet)	
and	$V = 1.49 \times R^{2/3} \times Sf^{1/2}/n$	(1002)
Where,	V = velocity of flow (feet per second)	
	R = hydraulic radius = A/WP (feet)	
	Sf = friction slope (feet per foot)	
	A = area of flow (square feet)	
	WP = wetted perimeter (feet)	
	n = Manning's roughness coefficient (Table I)	

Section 4.1.10.4.5 j. *Pipe form losses*. Generally, between the inlet and outlet, the flow encounters, in the flow passageway, a variety of configuration such as changes in pipe size, branches, bends, junctions, expansions and contractions. These shape variations impose losses in addition to those resulting from pipe friction. Form losses are the result of fully developed turbulence and can be expressed as follows:

	$HL = K (V^2/2g)$	(1003)
Where,	HL = head loss (feet)	
	K = loss coefficient	
	$V^2/2g$ = velocity head (feet)	
	g = gravitational acceleration (32.2 ft/sec^2).	

The following is a discussion of a few of the common types of form losses encountered in storm design.

(1) *Expansion losses*. Expansion losses in a storm sewer will occur when the sewer outlets into a channel. The expansion will result in a shearing action between the incoming high velocity jet and the surrounding outlet boundary. As a result, much of the kinetic energy is dissipated by eddy currents and turbulence. The loss head can be expressed as:

	$HL = Kx (V1^2/2g)(1-(A1/A2))^2$	(1004)
Where,	A = cross section area in square feet	

	V1 = average upstream pipe flow velocity, feet per second	
	Kx = expansion loss coefficient.	

Subscripts 1 and 2 denote the upstream and downstream sections respectively. The value of Kx is about one (1.0) for a sudden expansion (such as an outlet to a channel) and about two-tenths (0.2) for a well-designed expansion transition. Table II presents the expansion loss coefficient for various flow conditions.

Section 4.1.10.4.4 (2) *Contraction losses*. The form loss due to contraction is:

	$HL = Kc(V2^2/2g)(1-(A2/A1)^2)^2$	(1005)
Where,	Kc = Contraction loss coefficient	

Kc is equal to 0.5 for a sudden contraction and about 0.1 for a well-designed transition. Subscripts 1 and 2 denote the upstream and downstream sections respectively. Table II presents the contraction loss coefficient for various flow conditions.

Section 4.1.10.4.3 (3) *Bend losses*. The head losses for bends in excess of that caused by an equivalent length of straight pipe may be expressed by the relation:

	HL = Kb(V2/2g)	(1006)
Where,	Kb = Bend coefficient	

The bend coefficient has been found to be a function of: (a) the ratio of the radius of curvature of the bend to the width of the conduit, (b) deflection angle of the conduit, (c) geometry of the cross section of flow and (d) the Reynolds Number and relative roughness. Recommended bend loss coefficients for standard bends, radius pipe and bends through manholes are presented in Table II.

Section 4.1.10.4.5 (4) *Junction and manhole losses*. A junction occurs where one (1) or more branch sewers enter a main sewer, usually at manholes. The hydraulic design of a junction is in effect the design of two (2) or more transitions, one (1) for each flow path. Allowances should be made for head loss due to the impact at junctions. The head loss at a junction for each pipe entering the junction can be calculated from:

	$HL = (V2^2/2g) = Kj(V1^2/2g)$	(1007)
Where,	V2 = the outfall flow velocity	
	V1 = the inlet velocity	
	Kj = junction loss coefficient	

Because of the difficulty in evaluating hydraulic losses at junctions (Reference 6) due to the many complex conditions involving pipe size, geometry of the junction and flow combinations, a simplified table of loss coefficients has been prepared. Table II presents the recommended energy loss coefficients for typical manhole or junction conditions encountered in the urban storm sewer system.

(5) *Partially full pipe flow*. When a storm sewer is not flowing full, the sewer acts like an open channel and the hydraulic properties can be calculated using open channel.

Section 4.1.10.4.2

(6) *Storm sewer outlets*. When the storm sewer system discharges into an open channel, additional losses, in the form of expansions losses, occur at the outlet. For a headwall and no wing walls, the loss coefficient Ke is one (1.0). For a headwall with forty-five degree (45°) wing walls, the loss coefficient is about one and fourteen hundredths (1.14). For a flared-end-section (which has a D2/D1 ratio of two (2) and a theta angle of around thirty degrees (30°)) the loss coefficient is approximately one-half (0.5).

(7) *Connection pipes*.

(A) Connector pipes are used to convey runoff from an inlet to the storm sewer. If, however, the storm sewer runs through the inlet, then a connector pipe is not needed. Connector pipes can connect a single inlet to the storm sewer or they can be connected in a series.

(B) These bends, turns and flows through the connector pipe give rise to three (3) hydraulic losses: a change from static to kinetic energy to get the water moving through the connector pipe, an entrance loss from the inlet to the connector pipe and a friction loss along the length of the connector pipe. The total head loss in the connector pipe can be calculated from the following equation:

	Hcp = Hv + Ke x Hv + Sf x L	(1009)
Where,	Hcp = head loss in the connector pipe (feet)	
	Ke = Entrance loss coefficient	
	Hv = velocity head in the pipe, assuming full pipe flow (feet)	

and the other variables are as previously defined. The value of the entrance loss coefficient is determined from Table II.

(C) If the connector pipes are connected in series, the head loss in each pipe is calculated from Equation 1009 and the total head loss is the summation of the individual head losses.

Section 1.8.2.2

2. *Easements*. Easements shall be provided for all storm sewers constructed in the City of Republic that are not located within public rights-of-way. The minimum easement widths are as follows:

a. For pipes forty-eight (48) inches or less in diameter or width the required easement width is fifteen (15) feet.

b. For pipes and boxes greater than forty-eight (48) inches in width the required easement width is fifteen (15) feet plus half the width of the proposed storm sewer.

c. Storm sewers greater than eight (8) feet in depth to the flow line may require additional easement width.

d. All easements required for construction, which are not included on the final plat shall be recorded and filed with the City prior to approval of the construction drawings.

Section 5

C. *Design Standards For Culverts*.

Section 5.1 1. *Structural design*. All culverts shall be designed to withstand an HS-20 loading in accordance with the design procedures of AASHTO "Standard Specifications for Highway Bridges". The designer shall also check the construction loads and utilize the most severe loading condition. The minimum allowable cover is one (1) foot.

Section 5.2 2. *Design capacity*. Culverts shall be designed to pass a 25-year storm with one (1) foot of freeboard prior to overtopping the road or driveway.

Section 5.3 3. *Headwater*. The maximum headwater for the major storm design flow shall be one and one-half (1.5) times the culvert diameter for round culverts or one and one-half (1.5) times the culvert rise dimension for shapes other than round.

Section 5.4 4. *Inlet and outlet protection*. For road and driveway culverts larger than fifteen (15) inches, culverts are to be designed with protection at the inlet and outlet areas as provided in Section **410.710** of this criteria. Headwalls or end sections are to be located a sufficient distance from the edge of the shoulder or the back of walk to allow for a maximum slope of 3H:1V to the back of the structure. The type of outlet protection required is as follows:

V<7FPS	7FPS<V<15FPS	V>15FPS
Minimum Riprap protection	Riprap protection or Energy Dissipater	Energy dissipater

Section 5.5 5. *Velocity limitations*. The maximum allowable discharge velocity is fifteen (15) feet per second.

Section 5.6 6. *Culvert hydraulics*. It is recommended that the procedures outlined in the publication "Hydraulic Design of Highway Culverts" (reference 4) be used for the hydraulic design of culverts. Backwater calculations demonstrating the backwater effects of the culvert may be required.

Section 6

D. *Design Standards For Bridges.*

Section 6.1 1. *Structural design*. All bridges shall be designed to withstand an HS-20 loading in accordance with the design procedures of AASHTO "Standard Specifications for Highway Bridges" (reference 13). The designer shall also check the construction loads and utilize the most severe loading condition.

Section 6.2 2. *Design capacity*. Bridges shall be designed to pass the 100-year storm with one (1) foot of freeboard between the water surface and the bridge low chord.

Section 6.3 3. *Backwater. "Backwater*" is defined as the rise in the water surface due to the constriction created by the bridge approach road fills. The maximum backwater for the 100-storm design flow shall be one (1) foot.

Section 6.4 4. *Velocity limitations*. Discharge velocities through bridge openings shall be limited to fifteen (15) feet per second. Abutment and channel scour protection shall be provided at all bridges.

Section 6.5 5. *Bridge hydraulics*. All bridge hydraulics shall be evaluated using the procedures presented the publication "Hydraulics of Bridge Waterway" (reference 14). Backwater calculations demonstrating the effects of the bridge and approach fills compared to the existing flood stages shall be submitted for all bridges.

Section 7

E. *Design Standards For Open Channels*.

Section 7.1 1. *General design guidelines.*

Section 7.1.1 a. *Natural channels*. The hydraulic properties of natural channels vary along the channel reach and can be either controlled to the extent desired or altered to meet the given requirements. Natural channels used as part of the drainage system must be evaluated for the effects of increased peak flow, flow duration and volume of runoff due to urbanization.

Section 7.1.2 b. *Grass lined channels*. Grass lined channels are the most desirable of the artificial channels. The channel storage, lower velocities and the greenbelt multiple use benefits obtained create significant advantages over other artificial channels. Unless existing development restricts the availability of right of way, channels lined with grass should be given preference over other artificial types. The minimum slope in a grass-lined channel shall be one percent (1.0%) unless a concrete low flow channel is installed.

Section 7.1.3 c. *Concrete lined channels*. Concrete lined channels are sometimes required where right of way restrictions within existing development prohibit grass-lined channels. The lining must be designed to withstand the various forces and actions, which tend to overtop the bank, deteriorate the lining, erode the soil beneath the lining and erode unlined areas. The minimum slope in a concrete lined channel shall be one-half percent (0.50%).

Section 7.1.4 d. *Rock lined channels*. Rock lined channels are constructed from ordinary riprap or wire enclosed riprap (gabions etc.). The rock lining permits higher design velocity than for grass lined channels. Rock linings will normally be used only for erosion control at culvert/storm sewer outlets, at sharp channel bends, at channel confluences and at locally steepened channel sections.

Section 7.1.5 e. *Other lining types*. The use of fabrics and other synthetic materials for channel linings has increased over the past several years. Proposed improvements of this type will be reviewed on an individual basis as for applicability and performance.

Section 7.2 2. *Hydraulics*. An open channel is a conduit in which water flows with a free surface. The calculations for uniform and gradually varied flow are relatively straightforward and are based upon similar assumptions (e.g. parallel streamlines). The basic equations and computational procedures are presented in this Section.

Section 7.2.1 a. *Uniform flow*. Open channel flow is said to be uniform if the depth of flow is the same at every section of the channel. For a given channel geometry, roughness, discharge and slope, there is only one possible depth, the normal depth. For a channel of uniform cross section the water surface will be parallel to the channel bottom for uniform flow.

b. The computation of normal depth for uniform flow shall be based upon Manning's formula as follows:

	$Q = (1.49/n)AR^{2/3}S^{1/2}$

Where,	Q = Discharge in cubic feet per second (cfs)
	n = Roughness coefficient (Table I)
	A = Cross sectional flow area in square feet
	R = Hydraulic radius, A/P, in feet
	P = Wetted perimeter in feet
	S = Slope of the energy grade line (EGL) in feet/foot

For channels with a uniform cross section the EGL slope and the bottom slope are assumed to be the same.

Section 7.2.2 c. *Critical flow*. The design of earth or rock channels in the critical flow regime (Froude numbers from 0.9 to 1.2) is not permitted. The Froude number is defined as follows:

	$F = V/(gD)^{0.5}$
Where,	F = Froude number
	V = Velocity in feet per second (fps)
	g = Acceleration of gravity, 32.2 ft/sec^2
	D = Hydraulic depth in feet = A/T
	A = Cross sectional flow area in square feet
	T = Top width of flow area in feet

The Froude number shall be calculated for the design of all open channels.

Section 7.2.3 d. *Gradually varied flow*.

(1) The most common occurrence of gradually varied flow in storm drainage is the backwater created by culverts, storm sewer inlets or channel constrictions. For these conditions the flow depth will be greater than normal depth in the channel and the water surface profile must be computed using backwater techniques.

(2) Backwater computations can be made using the methods presented in Chow (reference 1). Many computer programs are available for computation of backwater curves. The most widely used program is HEC-2, Water Surface Profiles, developed by the U.S. Army Corps of Engineers (reference 2) and is the program recommended for backwater profile computations. Another program by the Federal Highway Administration is WSPRO and is acceptable for use in backwater computations.

Section 7.3 3. *Design standards*.

Section 7.3.1 a. *Flow velocity*. Maximum flow velocities shall not exceed the following:

Channel Type	**Max. Velocity**
Grass lined*	5 fps

Concrete	15 fps
Rock Lined	10 fps
*Refer to item f. below	

~~b. *Maximum depth*. The maximum allowable channel depth of flow is three (3) feet for the design flow.~~

Section 7.3.2 c. *Freeboard requirements*.

(1) "*Freeboard*" is defined as the vertical distance between the computed water surface elevation for the design flow and the minimum top of bank elevation for a given cross section.

(2) For all channels one (1) foot minimum of freeboard is required.

(3) Freeboard shall be in addition to super elevation.

Section 7.3.3 d. *Curvature*. The minimum channel centerline radius shall be three (3) times the top width of the design flow.

Section 7.3.4 e. *Super elevation*. Super elevation shall be calculated for all curves. An approximation of the super elevation h may be calculated from the following formula:

	$H = V^2T/(gr)$
Where,	h = Super elevation in feet
	V = Velocity in fps
	T = Top width of flow area in feet
	G = Acceleration of gravity, 32.2 ft/sec^2
	r = radius of curvature in feet

Freeboard shall be measured above the super elevated water surface.

Section 7.3.5 f. *Grass channels*.

Section 7.3.5.1 (1) Side slopes shall be three (3) (horizontal) to one (1) (vertical) or flatter. Steeper slopes may be used subject to additional erosion protection and approval from the City.

Section 7.3.5.2 (2) For design discharges greater than fifty (50) cfs, grade checks shall be provided at a maximum of two hundred (200) feet horizontal spacing.

Section 7.3.5.3 (3) Channel drops shall be provided as necessary to control the design velocities within acceptable limits.

Section 7.3.5.4 (4) Vertical drops may be used up to three (3) feet in height. Drops greater than three (3) feet shall be baffled chutes or similar structures.

Section 7.3.5.5 (5) The variation of Manning's n with the retardance and the product of mean velocity and hydraulic radius as shown in Figure 7.23 in reference 17 shall be used in the capacity calculations. Retardance curve C shall be used to determine the channel capacity and retardance curve D shall be used to determine the velocity.

Replaced with Section 1.8.2.2

~~4. *Easements.*~~

~~a. Easements shall be provided for all open channels constructed in the City of Republic that are not located within public rights of way. The minimum easement width for open channels is the flow width inundated by a 100-year event plus fifteen (15) feet.~~

~~b. All easements required for construction, which are not included on the final plat shall be recorded and filed with the City prior to approval of the construction drawings.~~

[Ord. No. 02-47 §§1 — 2, 11-25-2002; Ord. No. 04-19 §1, 3-8-2004]

Section 8

410.690 Stormwater Detention Design

Removed

A. *Purpose.*

1. Detention facilities are used to reduce storm water runoff rates by storing excess runoff.

2. The usual function of a detention facilities is to provide sufficient storage such that peak runoff rates are not increased when development occurs.

Section 8.1.1

B. *Policy*. The primary goal of the City of Republic stormwater management program is the prevention of flood damage to residential, commercial and public property. In adopting this policy, City of Republic recognizes that:

1. There are many areas in the City where residential flooding occurs because of inadequately sized drainage ways.

2. Flooding depths and frequency will increase as development occurs upstream of these areas.

3. Detention basins are the only effective "on-site" means which can be used to control peak runoff storm water rates as areas develop.

4. The City of Republic further recognizes that:

a. The best means to assure effective performance of a detention basin utilize is perform reservoir routing calculations using hydrographs.

b. Such methods have not been in widespread use in this area, but rather a method known as the "Simplified Volume Formula" has been the basis of City detention policy.

c. Use of the Simplified Volume Formula frequently does not result in adequately sized detention facilities.

d. The inaccuracy of the Rational Method upon which the Simplified Volume Formula is based increases as the area under consideration increases.

e. Even though the Simplified Volume Formula has severe limitations, requirement of detailed analytical methods may not be justified in all cases.

f. Detention basins designed using the Simplified Volume Formula do provide a minimal amount of flooding protection and potential water quality benefits by functioning as sediment basins.

Section 8.1.1

5. Therefore, in order to provide a reasonable level of flood protection to homes and businesses, while maintaining a climate favorable for development and economic growth, City of Republic has established the following policy for design of detention facilities.

C. *Methods of Analysis*. The method of analysis to be required for the design of detention facilities will be determined as follows:

Removed and replaced with Section 8.4

1. Detailed analysis will be required in the following cases:

   a. In areas where residences or other structures located downstream of a development can be shown to have an imminent flooding hazard a detailed analysis using hydrographs and reservoir routing techniques will be required.

   b. Residences or other structures will be defined as having an imminent flooding hazard when the lowest point, at which surface runoff may gain entry, is located at or below the estimated flooding level which would result from a storm with an annual probability of one percent (1%) or greater under conditions existing in the basin prior to development of the applicant's property (i.e., affected by the "100-year" storm).

   c. Consideration of downstream flooding problems will be limited to the area which may reasonably be expected to be significantly affected by runoff from the applicant's property.

   d. Detailed analysis will be required for all detention facilities where the peak runoff rate from the area upstream of the detention facility (off-site and on-site) exceeds fifty (50) cfs (cubic feet per second) for a storm with an annual probability of one percent (1%) (the "100-year" storm) under fully developed conditions.

   (Note: This would be the rate of flow from approximately twelve (12) acres for residential areas or five (5) acres for fully paved commercial areas.)

2. ~~Simplified analysis will be permitted in the following cases: For areas where there are no imminent downstream flooding problems and where the peak runoff rate from the drainage area (off-site and on-site) upstream of the detention facility does not exceed fifty (50) cfs for the one percent (1%) annual probability ("100-year") storm under fully developed conditions, the Simplified Volume Formula may be used.~~

3. *Alternatives to detention*.

   a. *Fee in lieu of detention*. In cases where channelization or other improvements can be shown to be more effective than detention in reducing the flooding hazard to downstream properties and where no adverse effects to downstream properties will result from construction of such improvements, the City may enter into an agreement with the applicant to accept compensation in lieu of constructing on-site detention facilities.

   b. The City has established the following formula for the fee in lieu of detention:

   Fee = K * (Ia) acres of impervious surface added

   Where Ia is the increase in impervious area (roofs, pavement, driveways, patios, etc.) in acres and K shall be determined as follows:

   K shall equal ten thousand dollars ($10,000.00) up to and including forty-three thousand five hundred sixty (43,560) square feet (one (1) acre) of impervious area added plus five thousand dollars ($5,000.00) for impervious area added in excess of forty-three thousand five hundred sixty (43,560) square feet (one (1) acre).

K is a factor determined by the City. This factor is based upon the net financial gain, which the developer would realize if the detention facility is not built. This amount will generally be equal to the construction cost of the detention facility plus revenue from sale of additional lots or increased value of lots, less the cost of developing the lots, including utilities and streets, financing costs, sales costs and reasonable profit. The City shall evaluate this formula annually and make the appropriate adjustments.

Removed

c. *Criteria for approving an alternative to detention*. The City will evaluate each request for an alternative design or fee in lieu of detention based on the following criteria. The City of Republic reserves the right to set precedent with each case considered depending upon the unique circumstances surrounding each request.

(1) Size of site in relation to the stormwater generated.*

(2) Size of the site in relation to the drainage area.*

(3) Impact on properties downstream of site.*

(4) Areas of concern as identified by the City of Republic's Stormwater Master Plan.

(5) Location of the site with respect to floodplains, streams or other large watercourses.

(6) Location of the site with respect to environmentally sensitive areas.

(7) Approval of previous requests.

* Downstream impacts shall generally be considered insignificant when the added upstream impervious area is less than ten percent (10%) of the total contributing watershed area. Exceptions to this rule include development where downstream areas are known to have an imminent flooding hazard as defined in Section **410.690**.

d. *Residential subdivisions*. Unless otherwise approved by the City, through review of stormwater calculations and criteria referenced herein, detention shall be required in all major residential subdivisions and the fee in lieu of detention established in Section 410.690(C-3(a)) shall apply. Upon request by a developer, the City may consider alternatives to the fee in lieu of detention in cases where it can be proven that the absence of detention will not adversely affect downstream property owners. Each request will be evaluated on a case-by-case basis and a fee in lieu detention may be established for the purposes of regional improvements within the watershed or abroad in the City.

Section 8.1.2

e. *Justified exceptions*. The City may consider, upon request, a waiver of detention and the fee in lieu for sites, in which the alteration of the site is inconsequential and will not substantially increase the runoff. A justified exception will be granted for sites based on the following criteria.

(1) Existing sites in which the addition of impervious surface will not increase more that five thousand (5,000) square feet.

(2) Sites in which existing gravel, chat or stone parking lots or driveways are paved with asphalt cement or concrete surfaces. This shall not apply to

parking areas or circulation routes in which vegetation has consumed the site and altered the ability to shed or absorb runoff. The City shall exercise strict discretion with respect to approving exceptions based on these criteria.

Section 8.1.2

(3) Sites in which a change in use has occurred, that does not increase the impervious area of the site.

(4) Subdivisions meeting the definition of a minor subdivision or the development of individual single-family-residential homes on individual lots in existing subdivisions.

f. *Procedure*. A request for approval of an alternative to detention must begin with the applicant providing the City with stormwater calculations for the increased runoff from the development. In addition to providing calculations, the applicant must submit a request for alternative design based on the criteria established above. The City Planner will coordinate review of the request with the Public Works Department, City Engineer or other departments impacted by the request. If the City determines the request is justified the City Planner will notify the applicant or his representative of the approval and the fee required in lieu of installing detention.

g. ~~*Minimum fee in lieu of detention established*. The City of Republic has established a minimum fee of one thousand one hundred fifty dollars ($1,150.00) in lieu providing detention to be paid upon approval by the City.~~

Section 8.1.3 4. *Innovation in design*.

a. It is the desire of the City that detention facilities be designed and constructed in a manner to enhance aesthetic and environmental quality of the City as much as possible.

b. The City of Republic therefore encourages designs, which utilize and enhance natural settings and minimize disturbance and destruction of wooded areas, natural channels and wetlands.

5. ~~*Interpretation*~~.

a. ~~Interpretations of the detention policy will be made by the City Engineer or City Planner in writing.~~

b. ~~Appeals of the decisions of the City Engineer or City Planner may be made, in writing, to the Community Development Director.~~

Section 8.3

D. *Design Criteria*.

1. *General*.

a. Detention facilities shall discharge into a drainage easement or public right-of-way.

b. One (1) foot of freeboard shall be provided between the maximum water surface elevation (maximum stage for a one percent (1%) annual probability event) and the minimum top of berm or wall elevation.

c. Embankment slopes steeper than three (3) horizontal to one (1) vertical (3H:1V) are not permitted.

d. In certain instances, such as when the existing development conditions runoff from a watershed would exceed the capacity of the existing downstream facilities, retention basins (i.e., no outlet or with a release rate at the capacity of the downstream facilities) for the storm runoff may be required by the City.

e. Dry detention basins shall maintain a minimum bottom slope of two (2) feet per hundred (100) feet (two percent (2%)).

f. Trickle channels shall have a minimum slope of one-half (0.5) foot per hundred (100) feet (one-half percent (0.5%)).

g. The maximum allowable depth of ponding for parking lot detention is twelve (12) inches.

h. Parking lot detention may not inundate more than ten percent (10%) of the total parking area.

i. All parking lot detention areas shall have a minimum of two (2) signs posted identifying the detention pond area. The signs shall have a minimum area of one and one-half (1.5) square feet and contain the following message:

WARNING:
This area is a storm water detention pond and is subject to periodic flooding to a depth of twelve (12) inches.

j. The sign shall be reflective and have a minimum height of forty-eight (48) inches from the bottom of the sign to the parking space finished grade. Any suitable materials and geometry of the sign are permissible, subject to approval by the City.

2. *Detailed analysis*.

a. Detailed analysis shall be performed using hydrograph methodologies and reservoir routing techniques.

b. The most common techniques are those developed by the Corps of Engineers and the Soil Conservation Service. These methods are preferred, however other proven techniques will be accepted.

c. Detention basins designed by detailed methods shall be designed on the basis of multiple storm recurrence frequencies to ensure that they function properly for both frequent storms and large infrequent storms.

d. A minimum of three (3) recurrence frequencies, the fifty percent (50%), ten percent (10%) and one percent (1%) annual probability storms (the "2-year, 10-year and 100-year" storms) must be considered.

e. The runoff model must include the entire drainage basin upstream of the proposed detention pond. The model shall be prepared in sufficient detail to ensure that peak runoff rates are reasonably accurate.

f. The runoff model shall be developed for the following cases:

(1) Case 1: Existing conditions in the drainage basin prior to development of the applicant's property.

(2) Case 2: Existing conditions in the drainage basin with developed conditions on the applicant's property.

(3) Case 3: Fully developed conditions in the entire drainage basin.

(4) Cases 1 and 2 are utilized to determine the required detention volume and the type of outlet structure to be provided and shall be analyzed for the three (3) storm recurrence frequencies required above.

(5) The detention facility shall be designed such that peak outflow rates from the facility for Case 2 are no greater than the rates determined in Case 1 for each of the three (3) storm recurrence frequencies required.

(6) The storage volume provided shall not be less than the difference in total runoff volume between Case 1 and Case 2.

(7) Case 3 is used determine the size of the overflow spillway. Case 3 need only be analyzed for the one percent (1%) annual probability ("100-year").

(8) The overflow spillway will, in most cases, be combined with the outlet structure.

Section 8.5

3. *Submittals*. The following information must be submitted for detention ponds designed by detailed methods:

Section 8.5.1

a. Information regarding analytical methods and software to be used, including:

(1) Name of software to be used.

(2) Type and distribution of precipitation input.

(3) Method for determining precipitation losses.

(4) Type of synthetic hydrograph.

(5) Method for routing hydrographs.

(6) Method used for reservoir routing.

Section 8.5.2

b. Map(s) showing sub-basin delineation, topography, presumed flow routes and pertinent points of interest; soil types; existing basin development conditions used in the model; fully developed conditions used in the model.

c. Routing diagram for the runoff model.

d. A summary of sub-basin characteristics used for program input.

e. Stage-area or stage-storage characteristics for the basin in tabular or graphic form.

f. Stage-discharge characteristics for the outlet structure and overflow spillway in tabular or graphic form; hydraulic data for weirs, orifices and other components of the control structure.

g. A printout of the input data file.

h. A summary printout of program output, including plots of hydrographs. (These are intended to be the printer plots generated by the software.)

Removed

4. *Simplified analysis*.

a. *Method of evaluation*. Differential runoff rates shall be evaluated by equation:

	R = (Cd X I100) - (Cu X I100)
Where,	R = Differential Runoff Factor

	Cd = Runoff Coefficient for developed conditions
	Cu = Runoff Coefficient for developed conditions
	I100 = Intensity for 100-year storm

b. "C" values shall be determined from the following table:

SUGGESTED RUNOFF COEFFICIENTS	
"C" Value	**Surface Conditions**
.10—.15	Tall grass, brush
.15—.20	Parks, golf courses, farms and one (1) acre single-family residences
.35	Single-family residences on lots of not less than 15,000 sq. ft.
.45	Single-family residences on lots of not less than 10,000 sq. ft.
.47	Single-family residences on lots of not less than 7,500 sq. ft.
.51	Single-family residences on lots of not less than 6,000 sq. ft.
.90	Gravel surfaces.
.95	Asphalt and concrete surfaces.
1.00	Buildings and other structures.

c. *Volume of Detention*. Volume of detention shall be determined according to the "Simplified Volume Formula", as follows:

V = R X A X tc (min.) x 60 (sec./min.)
V = Total volume of detention (cu. ft.)
R = Differential Runoff Factor
A = Area of project in acres
tc = Time of concentration (5 minutes, minimum)

d. *Time of Concentration*.

(1) *SCS Method*. The preferred method for determining time of concentration shall be the method set forth in Chapter 3 of the Soil Conservation Service Technical Release No. 55, "Urban Hydrology for Small Watersheds", 2nd Edition, 1986.

(2) *Other Methods*.

(A) Time of concentration may also be calculated by other accepted methods providing reasonable results.

(B) The time of concentration used in the formula shall be determined based upon existing conditions.

e. *Rainfall Intensity*. Rainfall intensity shall be determined from Drawing 20.

f. *Required Volume*. The required volume of detention shall be determined from the following Table:

Calculated Volume	**Required Volume**
1 cu. ft. thru 500 cu. ft.	500 cu. ft.
501 cu. ft. through 5,999 cu. ft.	Round up to nearest 500 cu. ft.
5,000 cu. ft. through 9,999 cu. ft.	Round up to nearest 1,000 cu. ft.
10,000 cu. ft. thru 49,999 cu. ft.	Round up to nearest 5,000 cu. ft.
Above 50,000 cu. ft.	Round up to nearest 10,000 cu. ft.

Section 8.6 5. *Control structures*.

a. Detention facilities designed by the simplified analysis shall be provided with obvious and effective outlet control structures. These outlet structures may include v-notch weirs or rectangular weirs, as well as pipe. Plan view and sections of the structure with adequate detail shall be included in plans.

b. The design discharge (Q) for the low-flow outlet shall not exceed the existing runoff for the one-year storm. The maximum discharge shall be designed to take place under total anticipated design-head conditions. The design-head storage volume is not to be considered a part of the volume of detention required.

c. Sizing of a low-flow pipe shall be by inlet control.

d. Low-flow pipes shall not be smaller than four (4) inches in diameter to minimize maintenance and operating problems, except in parking lot and roof detention where minimum size and configuration of opening shall be designed specifically for each condition.

e. Overflow spillways will be required on all detention facilities, which have storage volumes of one thousand (1,000) or more cubic feet.

f. The overflow opening or spillway shall be designed so that the combination flow of the low flow outlet and the flow over the spillway will not exceed the total peak runoff for the improved area. The total peak runoff is to be determined from a 25-year frequency rain for drainage areas less than one (1.0) square mile and from a 100-year frequency rain for drainage areas one (1.0) square miles or greater.

[Ord. No. 02-47 §§1 — 2, 11-25-2002]

Section 9

410.700 Sinkholes And Karst Features

Section 9.1 A. *General.*

1. The City of Republic is located on the Springfield Plateau of the Ozarks physiographic region. This area is underlain by Mississippian Age limestone, which is highly susceptible to solutional weathering. As a result, sinkholes, springs and caves are common.

2. In many areas of the City special consideration must be given to flood hazards and potential for groundwater contamination due to the presence of sinkholes, caves, losing

streams, springs and other features associated with karst geology.

3. The requirements set forth herein, are intended to provide specific criteria for design and construction for any site upon which sinkholes or other karst features are located.

4. Interpretations of these requirements shall be made and appeals may be made according to the procedures set forth in these Design Criteria.

Section 9.2 B. *Policy*. In keeping with the intent of the City Development Regulations the following policy is set forth for development in areas containing sinkholes:

1. Development in sinkhole areas will be based upon the following axioms:
   a. Avoidance.
   b. Minimization.
   c. Mitigation.

2. Construction in sinkholes shall be avoided. Exceptions will be made only in situations where it can be conclusively demonstrated that there are no practical alternatives to such construction.

3. These situations are mostly likely to arise where:
   a. An underground cavity has caused a collapsed sinkhole to form, after subdivision approval or building construction.
   b. A sinkhole has been altered or filled either unknowingly or prior to passage of these regulations.
   c. Maintenance and operation is required for existing roads and utilities.
   d. Location of existing streets or utilities would render access or utility service to a property impractical or cost prohibitive.

4. In these types of cases, measures, which will have minimal impact on the sinkhole or receiving water, may be proposed. Plans for minimal alteration can be approved provided it is conclusively demonstrated that the proposed plan is the minimum practical alternative.

5. In these cases potential impacts of construction on the sinkhole and receiving waters must be studied and assessed and recommendations made for mitigation of potential impacts upon surface flooding and groundwater quality before the plans can be approved. The degree and sophistication of study required will increase in proportion to the potential impacts.

Section 9.3 C. Definitions. As used in this Section, the following terms shall have these prescribed meanings:

ALTERED SINKHOLE
A sinkhole that has been filled, excavated or otherwise disturbed.

COLLAPSED SINKHOLE
A subsidence or cave-in of the ground surface caused when soil overburden can no longer be supported by underlying strata due to the presence of subsurface solution cavities.

HEAVY EQUIPMENT
Motorized equipment having a gross weight of more than six (6) tons.

Section 9.3 **LIGHT EQUIPMENT**
Motorized equipment weighing six (6) tons or less.

QUALIFIED GEOLOGIST
A person who has met or exceeded the minimum geological educational requirement and who can interpret and apply geologic data principles and concepts and who can conduct field or laboratory geologic investigations (per RSMo.) and who by reason of experience and education, has an understanding of local karst geology.

QUALIFIED PROFESSIONAL ENGINEER
A person registered to practice engineering according to the laws of the State of Missouri and who by reason of technical education and experience has a background in the fundamentals of storm drainage and karst **geology.**

SINKHOLE
Any depression in the surface of the ground, with or without collapse of adjacent rock that provides a means through which surface water can come into contact with subsurface water.

Sinkhole depressions may be gradual or abrupt; they may or may not have a well defined eye. While most sinkholes can be defined as the area within a "closed contour", some sinkholes such as those located on the sides of hills may not.

All sinkholes provide discreet points of recharge to groundwater.

SINKHOLE CLUSTER AREA
An area containing two (2) or more sinkholes located in close proximity, generally interconnected by groundwater conduits.

SINKHOLE EYE
Generally, a visible opening, cavity or cave in the bottom of a sinkhole, sometimes referred to as a swallow hole.

SINKHOLE FLOODING AREA
The area inundated by runoff from a storm with an annual exceedance probability of one percent (1%) and a duration of twenty-four (24) hours.

SINKHOLE RIM
The perimeter of the sinkhole depression. The sinkhole rim will generally vary in elevation.

SINKHOLE WATERSHED
The ground surface area that provides drainage to the sinkhole. This area extends beyond the sinkhole depression and generally crosses property boundaries.

TERMINAL SINKHOLE
The lowest sinkhole in a sinkhole cluster to which any surface water overflowing from other sinkholes in the cluster will flow.

UNALTERED SINKHOLE
A sinkhole that has never been altered or disturbed.

Section 9.4 D. *Permits Required*.

Section 9.4.1 1. *Grading permit*. A grading permit must be obtained prior to any alteration of sinkholes associated with new subdivision construction in accordance with the City's Subdivision

Regulations. Procedures and requirements for grading permits are set forth in Section **410.710**.

Section 9.4.2 2. *Other permits*. Other permits from State or Federal agencies may be required, as outlined in Section **410.650** of these Design Criteria, depending upon the size and nature of the proposed activity.

Section 9.5 E. *General Plan Requirements*. General requirements for grading and drainage plans are set forth in Sections **410.670, 410.680** and **410.710** of these Design Criteria.

Section 9.6 F. *Sinkhole Evaluation*. An evaluation including the following information shall be made for all sites upon which sinkholes are fully or partially located:

Section 9.6.1 1. The site plan for the proposed development must show the following items with respect to location of proposed construction, proposed or existing property lines and existing structures:

Section 9.6.1.1 a. Sinkholes.

(1) Location and limits of the area of the sinkhole depression as determined by field surveys or other reliable sources as may be approved.

Location of sinkholes based solely upon USGS 7-1/2 Minute Series Quadrangle Maps will not be considered sufficient unless field verified.

(2) Location and elevation of the sinkhole eye where visible or known.

(3) Topographic contours at maximum intervals of two (2) feet and spot elevations sufficient to determine the low point on the sinkhole rim and the profile of the potential overflow area.

(4) Minimum entry elevations of any existing structures located within the sinkhole rim.

(5) Elevation of any roadway located within or adjacent to the sinkhole.

Section 9.6.1.2 b. *Water supply sources*.

(1) The approximate location of public or private water supply sources such as springs or wells, as determined from information available from the City and Missouri Department of Natural Resources.

(2) Boundaries of any known recharge areas to wells or springs as determined from information available from the City and Missouri Department of Natural Resources.

Section 9.6.1.3 c. *Other geologic features*. Location of caves, springs, faults and fracture trends, geologic mapping units based upon information from the City or other reliable sources.

Section 9.6.1.4 d. Flooding limits for the sinkholes determined as set below.

Section 9.6.2 2. A drainage area map showing the sinkhole watershed area. Where the site is located in a sinkhole cluster area, this map shall be extended to include the watershed area any sinkholes located downstream of the site which may receive overflow drainage from the site.

Section 9.6.3 3. Assessment of potential impacts on groundwater quality and proposed water quality management measures as set forth below.

Section 9.7 G. *Flooding Considerations*.

Section 9.7.1 1. *Minimum flooding analysis*.

a. Maximum estimated flooding elevations shall be determined for each sinkhole for both pre-development and post development conditions, assuming no subsurface outflow from the sinkhole.

b. Where the estimated volume of runoff exceeds the volume of the sinkhole depression, the depth, spread and path of overflow shall be estimated and shown on the map.

c. The overflow volume shall be included determining the maximum estimated flooding elevations in the next downstream sinkhole. This analysis shall continue downstream until the lowest sinkhole of the sinkhole cluster is reached or overflow reaches a surface watercourse.

d. The volume of runoff considered shall be that which results from a rainstorm with an annual probability of one percent (1%) (100-year storm) and a duration of twenty-four (24) hours (eight and two-tenths (8.2) inches for Republic).

e. The runoff volume shall be determined by the method set forth in Chapter 2 of the SCS TR-55 Manual (Reference).

f. No further flooding analysis will be required provided that:

(1) The post-development flooding area of any sinkhole which receives drainage receiving drainage from the site is located entirely on the site.

(2) A drainage easement covering the post-development flooding area is provided for any off-site sinkhole or portion of a sinkhole which receives increased peak rates of runoff from the site. If the receiving sinkhole is not contiguous to the site, an easement must also be provided for the waterway that connects the site to the sinkhole.

(3) The minimum entry elevation of any existing structure is at least one (1) foot higher than the estimated flooding elevation from the one percent (1%) annual probability 24-hour storm.

(4) The flooding depth on any existing public road does not exceed the maximum depths set forth in Section **410.680**.

Section 9.7.2 2. *Detailed flooding analysis*.

Section 9.7.2.1 a. In cases where the conditions set forth above cannot be met, a detailed flooding analysis will be required if any increase in runoff volume is proposed. For detailed flooding analysis a runoff model must be made for the sinkhole watershed and reservoir routing analysis performed using hydrograph techniques as set forth in Section **410.690**.

Section 9.7.2.2 b. The following alternative methods may be used singly or in combination to keep flooding levels at predevelopment levels:

Section 9.7.2.2.1 (1) *Diversion of excess runoff to surface watercourses*. Where feasible, increased post-development runoff may by diverted to a surface watercourse, provided that:

(A) Any increase in peak runoff rate in the receiving watercourse does not create or worsen existing flooding problems downstream; and

(B) The diverted stormwater remains in the same surface watershed.

(C) Storm sewers, open channels and other appurtenances provided for diversions shall be designed in accordance with applicable sections of these Design Criteria.

(D) The effect of diverted water on downstream watercourses and developments and requirements for additional detention facilities prior to release of runoff to the surface watercourse shall be determined as set forth in Section **410.690**, Detention Facilities.

(E) Effects of the diversion shall be shown by reservoir routing analysis. Routing of excess runoff shall be considered satisfactory when it can be demonstrated that the post-development flooding elevation in the sinkhole does not exceed the pre-development flooding elevation within reasonable tolerance (generally one-tenth (0.1) foot).

Section 9.7.2.3 c. *Storage of excess runoff within the sinkhole watershed*.

(1) Where feasible, detention facilities may be constructed within the sinkhole watershed or in perimeter areas of the sinkhole. These detention facilities must be located outside the sinkhole flooding area determined for post-development conditions.

(2) The flooding considerations set forth in this Section will be met if it can be demonstrated that:

(A) Inflow rates to the sinkhole can be reduced to a degree that, in conjunction with the observed outflow rate, the post-development flooding elevation in the sinkhole does not exceed the pre-development flooding elevation within reasonable tolerance (generally one-tenth (0.1) foot).

(B) Sediment and erosion control and water quality considerations as set forth elsewhere in this Section can be satisfied.

Section 9.8 H. *Water Quality Considerations*.

Section 9.8.1

1. Sinkholes provide direct recharge routes to groundwater. As a result water quality in wells, caves and springs may be affected by discharge of runoff from developed areas.
2. The Sinkhole Evaluation must consider potential impacts of the proposed construction on receiving groundwater and propose measures to mitigate such impacts.
3. Four (4) primary factors must be considered:
    a. Receiving groundwater use.
    b. Relative groundwater contamination hazard associated with the proposed development.
    c. Ability to capture pollutants.
    d. Management measures to be provided to reduce pollutant levels.

Section 9.8.2 4. *Receiving groundwater use*.

a. The Sinkhole Evaluation Report shall identify whether the site lies within a critical area based upon information available from the City.

Section 9.8.2.1 b. Where disagreements may arise over whether a site is located within a particular recharge area dye tracing may be required for confirmation of the destination of water discharges through a sinkhole.

Section 9.8.2.2 c. *Critical areas*. The following areas are classified as critically sensitive to contamination from urban runoff:

(1) Recharge areas of domestic water supply wells.

(2) Recharge areas of springs used for public or private water supply.

(3) Recharge areas of caves providing habitat to rare or endangered species such as the Ozark cave fish.

Section 9.8.2.3 d. *Sensitive areas*. All other sinkhole areas will be classified as sensitive to contamination from urban runoff.

Section 9.8.3 5. *Groundwater contamination hazard*. The relative potential for groundwater contamination will be classified as low, moderate or high depending upon the type of land use, development density and amount of directly connected impervious area. The Sinkhole Evaluation shall identify whether the proposed development poses a low, moderate or high hazard to groundwater uses, as defined below:

Section 9.8.3.1 a. *Low hazard*. The following land uses are classified as posing a relatively low hazard to groundwater contamination:

(1) Wooded areas and lawns.

(2) Parks and recreation areas.

(3) Residential developments on sewer, provided directly connected impervious areas discharging to the sinkhole is less than one (1) acre.

(4) Low density commercial and office developments provided directly connected impervious areas discharging to the sinkhole is less than one (1) acre.

(5) Discharge from graded areas less than one (1) acre having required sediment controls per Section **410.710**.

Section 9.8.3.2 b. *Moderate hazard*.

(1) Concentrated discharge from streets and parking lots and roofs and other directly connected impervious areas having an area greater than one (1) acre and less than five (5) acres.

(2) Multi-family residential developments and higher intensity office developments provided the directly connected impervious areas discharging to the sinkhole is less than five (5) acres.

(3) Discharge from graded areas greater than one (1) acre and less than five (5) acres having required sediment controls per Section **410.710**.

Section 9.8.3.3 c. *High hazard*.

(1) Collector and arterial streets and highways used for commercial transport of toxic materials.

(2) Railroads.

(3) Concentrated discharge from streets and parking lots and roofs and other directly connected impervious areas having an area greater than five (5) acres.

(4) Commercial, industrial and manufacturing areas.

(5) Individual wastewater treatment systems.

(6) Commercial feedlots or poultry operations.

(7) Discharge from graded areas greater than five (5) acres having required sediment controls per Section **410.710**.

Section 9.8.4 6. *Capturing and filtering pollutants*.

a. The majority of sinkholes drain a limited watershed area. For sinkholes where the surrounding drainage area is small enough that the area draining to the sinkhole flows predominantly as "sheet flow", potential impacts on water quality can be addressed by erecting silt control barriers around the sinkhole during construction and providing a vegetative buffer area around the sinkhole to filter out potential contaminants.

b. When the volume of runoff into the sinkhole increases to the point where flow becomes concentrated, the degree of effort required to capture and filter out contaminants increases significantly.

c. Concentrated inflow occurs naturally when the sinkhole watershed area reaches a sufficient size for watercourses leading into the sinkhole to form. Concentrated surface flows result as urbanization occurs due to construction of roads, storm sewers, drainage channels. Subsurface flows can become concentrated through utility trenches.

d. The Sinkhole Evaluation shall include maps showing any existing watercourse which flows into the sinkhole and location of any proposed concentrated storm water discharges into the sinkhole.

Section 9.8.5 7. *Water quality management measures*.

Section 9.8.5.1 a. *Sediment and erosion control*.

Section 9.8.5.1.1 (1) *Non-concentrated flow (sheet flow)*. In critical areas, existing ground cover shall not be removed within twenty-five (25) feet of the sinkhole rim and a silt barrier shall be provided around the outer perimeter of the buffer area.

Section 9.8.5.1.2 (2) *Concentrated flow*. A sediment basin will be required at each point where concentrated flows are discharged into the sinkhole.

Sediment basins shall be designed according to the procedures set forth in Section **410.710**.

Section 9.8.5.2 b. *Minimizing directly connected impervious area*.

(1) The groundwater contamination hazard category for impervious areas may be reduced by reducing the amount of Directly Connected

Impervious Area. This is the area of roofs, drives, streets, parking lots, etc. which are connected via paved gutters, channels or storm sewers.

(2) Directly Connected Impervious Areas can be reduced by providing properly sized grass swales, vegetative filter strips or other Best Management Practices to separate paved areas.

Section 9.8.5.3 c. *Diversion of runoff*.

(1) Concentrated discharges to sinkholes can be reduced to manageable levels or avoided by diverting runoff from impervious areas away from sinkholes where possible.

(2) Diversions shall be done in a manner that does not increase flooding hazards on downstream properties and, generally, shall not be directed out of the surface watershed in which the sinkhole is located.

Section 9.8.5.4 d. *Filtration areas*.

(1) For areas having a low or moderate groundwater contamination hazard and where flow into the sinkhole occurs as sheet flow, water quality requirements can be satisfied by maintaining a permanent vegetative buffer area with a minimum width of thirty (30) feet around the sinkhole.

(2) Use of pesticides and fertilizers will not be permitted within the buffer area. Animal wastes will not be permitted to accumulate in the buffer area.

Section 9.8.5.5 e. *Grassed swales and channels*.

(1) For areas having a low groundwater contamination hazard concentrated flows from directly connected impervious areas of less than one (1) acre may be discharged into the sinkhole through grassed swales and channels.

(2) Swales and channels shall be designed for non-erosive velocities and appropriate temporary erosion control measures such as sodding or erosion control blankets provided.

Section 9.8.5.6 f. *Storage and infiltration*.

(1) Storage and infiltration will be required in the following cases:

(A) All areas having a high groundwater contamination hazard.

(B) Areas having a moderate groundwater contamination hazard where concentrated inflow occurs.

(2) Storage and infiltration basins shall be designed to capture the runoff from storms up to one (1) inch and release runoff over a minimum period of twenty-four (24) hours and maximum period of forty-eight (48) hours.

(3) Standards outlet structures for sedimentation and infiltration basins are shown in the standard drawings.

Section 9.9 I. *Development Requirements*.

Section 9.9.1 1. *Stormwater detention in sinkholes*.

a. Where flooding considerations and water quality considerations, as set forth in Section **410.710**, can be met, the volume of runoff storage in sinkholes can be counted toward storm water detention requirements, provided that proper sediment and erosion control measures are provided as set forth in Section **410.710**.

b. The volume of required detention storage shall be determined as set forth in Section **410.690**.

c. Excavation within the sinkhole flooding area to provide additional detention storage will not be allowed.

Section 9.9.2 2. *Modification of sinkholes to increase outflow rates*. Increasing outflow rates in sinkholes by excavating the sinkhole eye or installing disposal wells for diverting surface runoff to the groundwater system is prohibited, unless clear and imminent danger to the public health and safety can be demonstrated.

Section 9.9.3 3. *Setbacks and use restrictions*.

a. No new construction of any of the following shall be permitted within thirty (30) feet of the sinkhole rim:

(1) Residential, commercial or industrial structures.

(2) Swimming pools.

(3) Streets, highways or parking lots.

(4) Storage yards for materials, vehicles and equipment.

(5) Sanitary sewer lines.

b. Use of pesticides and fertilizers within thirty (30) feet of the sinkhole rim is prohibited.

c. Use of heavy construction equipment in unaltered sinkholes is prohibited.

d. Construction of underground utilities is prohibited within the sinkhole rim.

e. Recreational facilities such as hiking, jogging and bicycling trails, playgrounds, exercise courses and grass playing fields are permitted within the sinkhole area provided they are not located within the eye of the sinkhole.

f. Golf courses are permitted subject to approval of a Management Plan for use of pesticides and fertilizers.

g. Clearing and pruning of trees and undergrowth and limited grubbing of roots is permitted.

h. Landscaping and minor gardening is permitted outside of the sinkhole eye provided erosion and sediment discharge is limited through use of minimum tillage and mulches.

i. Construction of light incidental landscaping and recreational structures such as gazebos, playground equipment, etc. is permitted except in the sinkhole eye.

Section 9.9.4 4. *Collapsed sinkholes*.

a. Collapsed sinkholes may be stabilized and filled using approved techniques. A Grading Permit must be issued prior to performing any construction.

b. The probable cause of the collapse and potential adverse impacts of filling the collapse shall be investigated and information submitted with the Grading Permit application.

Section 9.9.5 5. *Altered sinkholes*.

a. Filling or altering of sinkholes without a Grading Permit constitutes a violation of these regulations. In such cases corrective measures must be proposed within the time period specified in the Zoning Regulations for enforcement of such violations. No corrective or remedial measures shall be undertaken until the proposed remediation plan has been reviewed by the City and a Grading Permit issued.

b. No Building Permits will be issued or zoning or subdivision approvals granted, until the remedial measures specified in the Grading Permit have been completed and approved.

[Ord. No. 02-47 §§1 — 2, 11-25-2002]

Section 10

410.710 Grading, Sediment And Erosion Control

Section 10.1 A. *Goals And Objectives*. The goal of the regulation is to effectively minimize erosion and discharge of sediment by application of relatively simple and cost effective Best Management Practices. This goal can be attained by meeting the following objectives:

1. Minimize the area disturbed by construction at any given time.
2. Stabilize disturbed areas as soon as possible by re-establishing sod, other forms of landscaping and completing proposed structures, pavements and storm drainage systems.
3. Provide for containment of sediment until areas are stabilized.
4. Provide permanent erosion controls.

Section 10.2

B. *General Design Guidelines*. The following items must be considered in preparing a sediment and erosion control plan:

Section 10.2.1 1. *Temporary versus permanent controls*.

a. The greatest potential for soil erosion occurs during construction. Temporary controls are those that are provided for the purpose of controlling erosion and containing sediment until construction is complete.

b. Temporary controls include straw or hay bale dikes, silt fences, erosion control blankets etc., which are not needed after the area is stabilized.

c. Permanent controls consist of riprap, concrete trickle channels, detention basins, etc., which will remain in place through the life of the development.

d. It is possible for the same facility to serve both a temporary and permanent purpose. The difference between temporary and permanent erosion control should be clearly recognized in preparing a sediment and erosion control plan.

Section 10.2.2 2. *Sheet flow versus concentrated flow*.

a. In areas where runoff occurs primarily as sheet flow, containment of sediment is relatively simple. In these areas straw or hay bales, silt fences and vegetative filter areas can be very effective.

b. Where concentrations of flow occur containment of sediment becomes more difficult as the rate and volume of flow increase. In these areas more sophisticated controls such as sedimentation basins must be provided.

Section 10.2.3 3. *Slope.* Control of erosion becomes progressively more difficult as the slope of the ground increases. Areas with steeply sloping topography and cut and fill slopes must be given special consideration.

Section 10.2.4 4. *Soils and geologic setting*. Area soils and the geologic setting must be considered in preparing the plan and any special considerations deemed necessary for a particular site provided.

Section 10.2.5 5. *Environmentally sensitive areas*. Where construction occurs within the vicinity of permanent streams, springs, sinkholes, lakes or wetlands, special attention must be given to preventing discharge of sediment.

Section 10.3

C. *Grading Permits*.

Section 10.3.1 1. *Permit requirements*. Grading permits are required for all construction sites with the following exceptions:

a. Grading for single-family or duplex residences constructed in subdivisions where approved sediment and erosion controls have been constructed.

b. Emergency construction required repairing or replacing roads, utilities or other items affecting the general safety and well being of the public.

c. For emergency construction sites which would otherwise be required to obtain a permit and for which remedial construction will take more than fourteen (14) calendar days, application for the permit must be made within three (3) calendar days from the start of construction.

d. The following activities, provided that they are not located within twenty-five (25) feet of a spring, sinkhole, wetland or watercourse:

(1) Gardening or landscaping normally associated with single-family residences that cover less than one-half (1/2) acre.

(2) Grading and repair of existing roads or driveways.

(3) Cleaning and routine maintenance of roadside ditches or utilities.

(4) Utility construction where the actual trench width is two (2) feet or less.

Section 10.3.2 2. *Permit procedure*. The following items must be received prior to issuance of a Grading Permit:

a. An approved grading, sediment and erosion control plan. The submittal and approval procedure is as follows for subdivisions, commercial and other sites.

(1) The sediment and erosion control plan shall be submitted for review along with the plans for the proposed improvements.

(2) Grading permits for commercial, multi-family or major subdivisions will be issued by the City Planner after the project plans have been approved.

Section 10.3.3 3. *Plan requirements*. Plans must be prepared by and bear the seal of, an engineer registered to practice in the State of Missouri. Plan requirements are set forth in Section **410.660** and in this Section. Plans will not be required in the following cases:

a. Grading associated solely with a single-family residence.

b. Grading or filling of less than one (1) acre if located outside of the allowable building areas and not located within twenty-five (25) feet of spring, sinkhole, wetland or watercourse. In these instances a grading permit can be issued, providing an inspection of the site by a representative of the City does not reveal conditions that would warrant preparation of a detailed plan.

Section 10.4

D. *Other Permits*.

Section 10.4.1 1. *NPDES storm water permit*. Effective October 1, 1992, construction sites where the area to be disturbed is five (5) acres or more must apply for a storm water discharge permit from the Missouri Department of Natural Resources. Permit requirements are set forth in 10 CSR 20-6.200 of the Missouri Clean Water Laws.

Section 10.4.2 - Added Missouri Land Disturbance Permit

Section 10.4.3 2. *"404" permit*. Grading activities in streams or wetlands may require a Department of the Army Permit under Section 404 of the Clean Water Act.

Section 10.5 E. *Design Standards And Criteria*.

Section 10.5.1 1. *Grading.*

Section 10.5.1.1 a. *Maximum grades*. Cut or fill slopes shall not exceed four (4) to one (1).

Section 10.5.1.2 b. *Maximum height*. Cut or fill slopes shall not exceed fifteen (15) feet in vertical height unless a horizontal bench area at least five (5) feet in width is provided for each fifteen (15) feet in vertical height.

Section 10.5.1.3 c. *Minimum slope*. Slope in grassed areas shall not be less than one percent (1%).

Section 10.5.1.4 d. *Construction specifications*. Construction for streets must comply with specifications set forth by the City of Republic. For all other areas, construction specifications stating requirements for stripping, materials, subgrade compaction, placement of fills, moisture and density control, preparation and maintenance of subgrade must be included or referenced on the plans or accompanying specifications submitted.

Section 10.5.1.5 e. *Spoil areas*.

(1) Broken concrete, asphalt and other spoil materials may not be buried in fills within proposed building or pavement areas.

(2) Outside of proposed building and pavement areas, broken concrete or stone may be buried in fills, provided it is covered by a minimum of two (2) feet of earth.

(3) Burying of other materials in fills is prohibited.

Section 10.5.1.6 f. *Stockpile areas*. Location of proposed stockpile areas shall be outlined on the plans and specifications for proper drainage included.

Section 10.5.1.7 g. *Borrow areas*. The proposed limits of temporary borrow areas shall be outlined in the plans and a proposed operating plan described on the grading plan. Temporary slopes in borrow areas may exceed the maximums set forth above. At the time that borrow operations are completed, the area shall be graded in accordance with the criteria set forth above and reseeded.

Section 10.5.2 2. *Sediment containment*.

Section 10.5.2.1 a. *Existing vegetative filter area*. Existing vegetative filter areas may be used where:

(1) Unconcentrated sheet flow occurs;

(2) An area of existing vegetation a minimum of twenty-five (25) feet in width can be maintained between the area to be graded and a property line, watercourse, sinkhole, spring, wetland or classified lake;

(3) Existing ground slope is no greater than five (5) to one (1) (twenty percent (20%));

(4) The existing vegetative growth is of sufficient density and in sufficiently good condition to provide for filtration of sediment.

(5) Vegetative filter areas are a temporary and permanent practice.

Section 10.5.2.2 b. *Hay/straw bale dike or silt fence*. Containment areas constructed of hay or straw bales or silt fence may be provided in areas where:

(1) Unconcentrated sheet flow occurs,

(2) An area of existing vegetation a minimum of twenty-five (25) feet in width cannot be maintained between the area to be graded and a property line, watercourse, sinkhole, spring, wetland or classified lake,

(3) Existing ground slope is no greater than five (5) to one (1) (twenty percent (20%)),

(4) Concentrated flow from an area no greater than one (1) acre occurs and a minimum volume of one thousand (1,000) cubic feet per acre is contained behind the dike. Either cereal grain straw or hay may be used for bale dikes. Straw/hay bale dikes shall be constructed as shown in Drawing 50. Straw/hale bale dikes and silt fences are temporary practices.

Section 10.5.2.3 c. *Temporary containment berms*.

(1) Temporary containment berms may be provided for areas where concentrated flow from areas greater than one (1) acre and less than five (5) acres occurs. Temporary containment berms must contain a volume of one thousand (1,000) cubic feet per acre of drainage area.

(2) Temporary containment berms shall have a riprap outlet with a sediment filter as shown in Drawing 40 or a perforated pipe outlet as shown in Drawing 80.

(3) Details for temporary containment berms are shown in Drawing 30.

(4) Temporary containment berms and accumulated sediment may be completely removed after the tributary area is stabilized and must be removed prior to final acceptance and release of escrow.

Section 10.5.2.4 d. *Sedimentation basin*.

Section 10.5.2.4.1 (1) Sediment basins shall be provided for all areas where concentrated flow occurs from an area of five (5) or more acres. Sediment basins shall be designed to detain the runoff from one (1) inch of rainfall for a period of at least twenty-four (24) hours.

Moved to Section 3.

Runoff shall be calculated using the methods contained in Chapter 2 of TR-55 (Reference 11), using the recommended curve number for newly graded areas from Table 2-2a.

Note: For construction sites in Republic an average value of runoff volume from one (1) inch of rainfall is approximately one thousand two hundred (1,200) cubic feet per acre, using a Curve Number of 90, as indicative of a mixture of type B and C soils. This value may be used in sizing sediment basins or the runoff volume determined using the values from Figure 2-1 of TR-55.

Section 10.5.2.4.2 (2) Sediment basins shall be provided with an outflow structure consisting of:

(A) A flow restriction device which provides for the required detention time,

(B) An outfall pipe sized to carry the maximum estimated outflow rate,

(C) Protective structures at the pipe outlet to prevent crushing or damage of the end of the pipe,

(D) Protective structures to prevent blockage of the pipe with debris,

(E) Erosion protection at the pipe outlet. A typical outlet structure is shown in Drawing 140.

Section 10.5.2.4.3 (3) An overflow spillway capable of discharging the peak flow rate for the four percent (4%) annual probability (25-year) storm while maintaining a minimum freeboard of one (1) foot.

(4) Overflow spillways may be sodded where the depth of flow at the crest is limited to no greater than six (6) inches and outlet channel velocities do not exceed five (5) feet per second for the minor (5-year) storm.

(5) Overflow spillways not meeting these restrictions must be constructed of riprap, concrete or other approved, non-erodible material.

Section 10.5.3 3. *Erosion protection*.

Section 10.5.3.1 a. *Seeding and mulching*.

Section 10.5.3.1.1 (1) *Permanent seeding*. Permanent seeding fertilizer and mulch shall be applied at the rates set forth in Drawing 10 or according to other specifications, which are approved with the Grading Permit.

(2) Permanent seeding seasons are from March first (1st) to May fifteenth (15th) and August fifteenth (15th) to October fifteenth (15th).

Section 10.5.3.1.2 (3) *Mulching.* Where slopes are less than four (4) to one (1), cereal grain mulch is required at the rate of one hundred (100) pounds per one thousand (1,000) square feet (four thousand five hundred (4,500) pounds per acre). Cereal grain mulch shall meet the requirements of Section 802 of the State Specifications (Reference 17) for Type 1 mulch.

(4) Where slopes are four (4) to one (1) or greater Type 3 mulch ("hydromulch") meeting the requirements of Section 802 of the State

Specifications (Reference 17) shall be used.

Section 10.5.3.1.3 (5) *Temporary seeding*. Whenever grading operations are suspended for more than thirty (30) calendar days between permanent grass or seeding periods, all disturbed areas must be reseeded with temporary cover according to Drawing 10.

Temporary seeding season runs from May fifteenth (15th) to November fifteenth (15th).

Section 10.5.3.1.4 (6) *Overseeding.* During the winter season (November fifteenth (15th) to March first (1st)) temporary seed and mulch shall be placed in on all completed areas or areas where grading is suspended for more than thirty (30) calendar days. During this period seed, mulch and soil amendments shall be applied at the following rates:

Lime: 100% of specified quantity.*
Fertilizer: 75% of specified quantity.
Seed: 50% of specified quantity.
Mulch: 100% of specified quantity.
* Per Drawing 10.

Areas seeded during this period shall be reseeded and mulched during the next permanent seeding season according to seeding requirements.

Section 10.5.3.1.5 (7) *Maintenance.* Seeded areas must be maintained for one (1) year following permanent seeding.

Section 10.5.3.2 b. *Cut and fill slopes*. Cut and fill slopes shall be protected from erosion by construction of straw bale dikes, silt fences, diversion berms or swales along the top of the slope.

(1) Where drainage must be carried down the slopes, pipe drains, concrete flumes, riprap chutes or other impervious areas must be provided. Suitable erosion control measures such as riprap stilling basins, must be provided at the bottom of the slope.

(2) Diversions shall be maintained until permanent growth is firmly established on the slopes.

(3) Typical diversion details are shown in Drawing 30. Riprap chute details are shown in Drawing 70.

Section 10.5.3.3 c. *Channels and swales*. Permanent channels and swales shall be provided with a stabilized invert consisting of one of the following materials:

Section 10.5.3.3.1 (1) *Sod.* Where the average velocity of flow is five (5) feet per second or less and there is no base flow, the channel shall be lined with sod.

(A) For channels with a bottom width less than fifteen (15) feet, sod shall extend up the side slope to a minimum height of six (6) inches above the toe. (Drawing 90).

(B) Channels with a bottom width of fifteen (15) feet or greater, shall be graded as shown in Drawing 90 and a low flow area, fifteen (15) feet in width lined with sod.

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(C) The remainder of the channel slopes shall be seeded and mulched as provided above.

Section 10.5.3.3.2 (2) *Erosion control blanket*. Commercial erosion control blankets may be used in lieu of sod provided that samples are submitted and approved by the City. The guaranteed maintenance period shall be one (1) year.

Section 10.5.3.3.3 (3) *Non-erosive lining*. In grass channels where base flow occurs, a non-erosive low-flow channel of riprap or concrete must be provided. Low flow channels shall have a minimum capacity of five (5) cubic feet per second. Other suitable non-erosive materials may be specified with approval of the City.

(4) For channels which have an average velocity of five (5) feet per second or greater a non-erosive lining of riprap concrete or other approved material must be provided.

Section 10.5.3.4 d. *Storm sewer and culvert outlets*. Erosion protection shall be provided at storm sewer and culvert outlets. Minimum erosion protection shall consist of a concrete toe wall and non-erosive lining, meeting the City's specifications for public improvements.

(1) The required length of non-erosive lining will not be decreased where flared end sections or headwalls are provided unless calculations and data to support the decrease in length are submitted and approved.

(2) Non-erosive lining shall consist of riprap, unless otherwise specified and approved. Field stone, gabions or riprap shall extend to the point at which average channel velocity for the peak flow rate from the minor (5-year) storm has decreased to five (5) feet per second maximum.

(3) The length of riprap to be provided shall be as follows: (See Drawing 120)

Average outlet velocity less than five (5) feet per second:
L = three (3) times the pipe diameter or culvert width.

Average outlet velocity less than five (5) to ten (10) feet per second:
L = length determined using Drawing 120.

Average outlet velocity greater than ten (10) feet per second:

(4) Use MHTD standard energy dissipater headwall. (Reference 17)

The height of erosion protection shall be as shown in Drawing 120.

(5) Minimum toe wall dimensions are shown in Drawing 120. Where headwalls or flared end sections are specified, toe walls must be provided at the downstream end.

Section 10.5.3.5 e. *Curb openings*. Where drainage has been approved by the City to flow from paved areas to grass areas through curb openings erosion protection shall be provided as shown in Drawing 130.

Section 10.5.3.6 f. *Ditch checks and drop structures*. In grass channels grades and velocities may be controlled by use of ditch checks and drop structures. Riprap ditch checks may be required in natural channels where average velocity for the peak flow rate from the 5-year storm exceeds five (5) feet per second for post-development conditions.

Section 10.5.3.7 g. *Spillways.* Erosion protection must be provided at spillways and outlet structures for detention ponds. Erosion protection shall extend to the point where flow has stabilized and average velocity in the outlet channel is five (5) feet per second or less.

Section 10.5.4 4. *Temporary construction entrance*.

a. A minimum of one (1) temporary construction entrance is required at each site. Additional temporary entrances may be provided if approved. The location of each construction entrance shall be shown on the plan.

b. Only construction entrances designated on the sediment and erosion control plan may be used. Barricades shall be maintained if necessary to prevent access at other points until construction is complete.

c. Construction entrances shall be constructed of crushed limestone meeting the following specifications:

(1) Construction entrances shall be a minimum of twenty-five (25) feet wide and fifty (50) feet long.

(2) Minimum thickness of crushed limestone surface shall be six (6) inches. Additional two (2) inch lifts of crushed limestone shall be added at the discretion of the County if the surface of the initial drive deteriorates or becomes too muddy to be effective.

(3) In locations where an existing drive or street extends at least fifty (50) feet into the site, the existing drive may be designated as the construction entrance and construction of a new gravel entrance is not required, unless job conditions warrant as set forth in the preceding paragraph.

Section 10.5.5 5. *Cleaning streets*. Streets both interior and adjacent to the site shall be completely cleaned of sediment at the end of construction and prior to release of security.

Section 10.5.6 6. *Dust control*. The contractor will be required to use water trucks to water all roads and construction areas to minimize dust leaving the site when conditions warrant.

Section 10.5.7 7. *Sequencing and scheduling*. Costs of sediment and erosion control can be minimized if proper consideration is given to sequencing and scheduling construction. Any special sequencing and scheduling considerations should be noted in the grading plan. A detailed schedule must be received from the contractor at the Pre-Construction Conference.

[Ord. No. 02-47 §§1 — 2, 11-25-2002]