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Residential Subdivisions Planning and Design Elements

by

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I. Introduction

This course discusses the main planning and design elements of residential subdivision development. After completing this course the reader should have a basic understanding of what type of information is needed, typical sources of information and what components are generally presented in the final design.

The planning elements consist mainly of the “big picture” items that tend to form or shape the development in a particular manner. Certain items tend to reduce the overall buildable area or require public review. For example, the zoning ordinance may restrict the density to a certain number of dwellings per acre or the ordinance may require a large percentage of open space in a particular location. There may even be floodplains which reduce your overall buildable area. As the word planning indicates, these things are done at the very beginning, before any design work begins.

A general, non-legal definition of a residential subdivision is: the division of a larger parcel of land into smaller lots for the purpose of providing home sites. There are different types of residential developments; for example, single family detached or attached homes, multifamily, apartments, duplexes, triplexes, townhouses or condominiums. The planning and design elements presented herein are applicable to these different types of developments as well. **Figure 1** is an example of a concept plan of a subdivision, showing some basic components.

The design elements are those components which enable the contractor to build the development to the pertinent design standards; for example, the street and lot layout, grading plan, water, sanitary and storm sewer design. By doing a thorough planning effort, the design process will have fewer changes and overall will be more efficient.

The development of a residential subdivision can be a lengthy and complex process with many different elements pushing and molding the design towards approval. It may be true in other fields of engineering but certainly it is in residential subdivision development; that

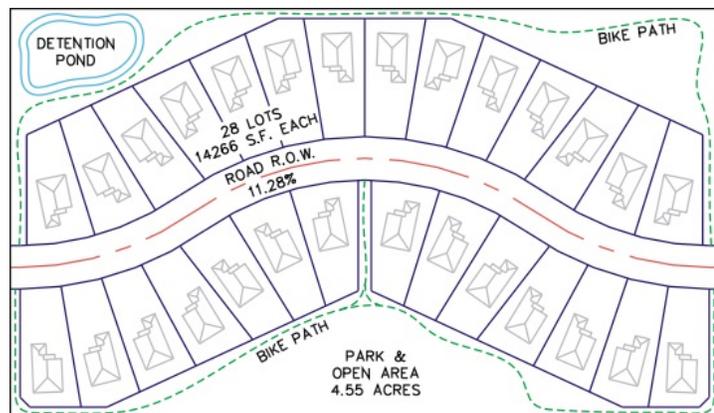


Figure 1. Coving Subdivision by Zephram Stark.
Accessed Apr. 2, 2018 from: <http://commons.wikimedia.org/>



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the pure science of it, such as design calculations, seem to be the only facets that are consistent from project to project. The other aspects, such as regulatory constraints, definitions and procedures, are quite variable and many times subject to differing interpretations; particularly if one works with multiple jurisdictions. Thus, project management, good communication and relationship building; along with design experience, are valuable skills in bringing the development to fruition.

II. Planning Elements

A. Developer Contact

Prior to commencing design, the engineer, designer or planner meets with the developer to determine if there is a particular vision in mind for the development. Some developers have a particular style, look or special amenities that they want to provide in their developments and they will closely coordinate with the engineer until final approval. Others may only want to subdivide their parcel, build the roads and infrastructure, and then sell to another developer for final build-out. A plat or boundary survey of the project parcel should be obtained at this point, from the developer, a surveyor, or through county land records.

After meeting with the developer, the engineer should have a good handle on just how much flexibility there is in terms of layout choices and amenities. If the developer wishes to design in phases, this is something that will need to be discussed early on with the city or county reviewers. Some municipalities may be reluctant to approve portions of a development without seeing at least a concept plan of the entire development.

In a contrasting situation, some larger civil engineering firms have their own planning department with experienced planners on staff. In these cases, the engineer may not necessarily have much involvement in the planning process or with the developer. The designer may be given an approved preliminary plan, and designs within that given framework, according to code requirements. The planning elements are, nonetheless, included herein to give a comprehensive understanding of the development process.



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B. Regulatory Constraints

The regulatory constraints discussed in the following paragraphs may be obtained from the local municipal codes, zoning ordinances, and federal and state regulations. Most are available on-line. If the municipality does not have on-line information it will be necessary to visit the town engineer, planning, zoning or public works departments to obtain copies of ordinances and important planning maps. Of course, not all of the following elements are applicable to all sites.

- **Floodplains -- Buffers**

Whether or not a land survey has been completed at the planning stage, it is still possible to do some preliminary research of floodplain locations via on-line GIS (Geographic Information System) websites. Normally, one can zoom in on a particular parcel and turn on or off various layers including topography and floodplains. If a 100-year floodplain exists on the project parcel and the desire is not to build in that floodplain then there will likely be some sort of buffer, maybe a 50 or 100 foot swath that will be designated as an undisturbed area. Using computer aided design tools; it is possible to copy a close approximation of the floodplain boundary onto the project parcel drawing. By depicting this boundary on the parcel, the buildable area begins to be more apparent.

- **Environmental Assessments**

This element covers a wide range of issues such as wetlands, endangered species, ground contamination, noise studies, historical, biological and cultural resources. Environmental firms and/or attorneys may assist in determining the extent of these assessments.

- **Dam inundation zone**

If the project site is in an area that may be downstream of a dam it would be prudent to examine maps, drive around the area, or talk to the county or state dam safety officials about the presence of dams. According to FEMA (Federal Emergency Management Agency) as of 2013, more than 65% of dams are privately owned and many lack the funds necessary for proper



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maintenance (https://www.fema.gov/media-library-data/20130726-1845-25045-7939/fema_p_956_living_with_dams.pdf). For this reason, the developer or owner should be made aware of this situation so that proper insurance and legal counsel can be pursued.

- **Conservation areas**

There may be areas designated by the local land use plan that are to be set aside as natural resource conservation areas. They may have plants, animals, water features, views, or other valuable community qualities that the county or town has set aside as non-development zones.

- **Open space requirements**

Open space dedication is often required for residential subdivisions. What this means is that a certain percentage of the development must remain either natural or perhaps landscaped as usable open space. Usable means something like a playground or a ball field. Sometimes a certain percentage of the previously mentioned buffers may count towards this requirement. It is always a good idea to get written confirmation from the local planner on any code or ordinance interpretation as sometimes their rules change and their website may not have been updated at the time research was conducted. A simple example of an open space requirement is shown in **Table 1**:

Development Type	Minimum open space as a percentage of site area
Residential lots greater than one acre to 5 acres	10%*
Residential lots greater than 5 acres to 20 acres	15%*
*50 % of open space requirement must be usable	

Table 1. Sample open space requirements.



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Example usable open space calculation:

For a 100 acre site area with 2 acre residential lots, calculate the **usable** open space requirement:

$$100 \text{ acre} \times 0.10 \times 0.50 = 5 \text{ acres usable open space}$$

One aspect of open space is the need for a formal written maintenance agreement to ensure that the open space is maintained properly.

- **Zoning**

Many times the project parcel will require rezoning from agricultural to residential. Since the rezoning process involves public review or hearings, early scheduling of this process is important. Some different designations of zoning are: rural residential, low density, medium density, high density, cluster and planned residential. The zoning ordinance is the primary source for this type of information.

- **On-site trails requirements**

This requirement is another item that will affect the lot and street placement. It may count, however, towards the open space requirement. The minimum widths vary greatly, so it is a good idea to get local government confirmation on this requirement.

- **Sidewalk requirements**

Sometimes sidewalks are only required along the primary roads to maintain connectivity to neighboring areas. If the development is to be a Low Impact Development (LID), traditional width concrete sidewalks may be prohibited.

- **Bicycle lanes**

Bicycle connectivity may be required. Minimum widths, specifications and special pavement striping are prescribed in the local design standards.



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- **Off-site easements**

If it is readily apparent that the water or sanitary sewer will have to be extended off-site, then easements will need to be acquired from the owners of the affected properties. Again, the planning stage is a good time to approach the owners and start that process. Sometimes owners wishing to connect to public sewer or water are favorable to granting easements.

- **Stormwater management**

Consult the subdivision development standards or the stormwater design manual to determine the requirements for stormwater management. If both water quality and water quantity management are required, then this will usually increase the amount of area needed for mitigation measures. Additionally, operation and maintenance agreements are usually required for stormwater management devices.

- **LID (Low Impact Development) requirements**

Many cities require Low Impact Development measures. Low Impact Development refers to designs which incorporate natural methods for stormwater management and reductions in overall impermeable surfaces. So for example, instead of using curb and gutter, storm inlets and piping; grassed shoulders and ditches would be utilized to divert runoff to swales. An example is shown in **Figure 2**.



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Figure 2. Example of LID measures. Accessed Apr. 2, 2018 from:
<https://www.epa.gov/sites/production/files/2015-09/documents/bbfs2terms.pdf>

- **Tree saving**

Some municipalities may have tree save requirements. Tree saving involves walking the site and identifying various species of trees which the municipality has defined as environmentally valuable. These trees will need to be marked and protected from damage during the construction process so it is important to determine this in the planning stage so that the layout plan avoids these areas.



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- **Screening**

Screening, in the form of fencing or landscaping, may be required if there is some type of use on the adjacent property that would be considered aesthetically unpleasant.

- **Entrance requirements**

Depending on the size of the proposed development, the primary road at which the new entrance will intersect may require a right turn lane, a left turn lane, or both. The local transportation department should be consulted. Among other data, the vehicles per day (VPD) and average daily traffic (ADT) of the proposed development is needed to make a determination. The Institute of Transportation Engineers' (ITE) *Trip Generation Manual* and the Transportation Research Board's *Highway Capacity Manual* are two sources for this information. A brief note about subdivision entrances; some municipalities are veering away from total cul-de-sac design and are requiring at least two entrance locations.

- **Proffers due to conditional zoning**

There are a few states which allow proffers in exchange for a particular type of rezoning. This basically means that the landowner voluntarily offers to either construct some amenity, such as a park, or offers money in lieu of the improvements.

- **Impact fees**

Impact fees are mandatory and pay for providing services such as schools, utilities, roads, or parks due to the increased demand on these services. This is included in the planning elements because some impact fees may prevent developers from proceeding with the development.

- **Soil testing**

Soil tests are needed to determine suitability for structural building requirements, road bearing capacity, and stormwater management purposes. A geotechnical engineer provides this type of service.



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- **Underground utility location**

Many seemingly untouched properties have old abandoned underground utility lines as well as current active lines. A subsurface utility engineering (SUE) firm helps research and locates these lines, thereby reducing costly surprises.

- **Existing easements**

While this element will be accurately detailed on the survey map at the plan development phase, many times this information is easily accessible on county or utility websites. Sketching or copying them onto your preliminary plan will help identify conflicts early in the process.

- **Fire protection plans**

Fire protection plans are sometimes needed in high fire hazard areas such as the southwest part of the country. Identifying fire service (stations) availability is important for all subdivisions even if a fire protection plan is not required.

- **Water and sanitary sewer availability**

Meeting with the local utility companies in the planning stages will help determine if there is availability and capacity for the new development. A formal acceptance letter may be required. In the case of on-site septic tanks and water wells, usually the local department of health or environmental health can furnish required regulations. A community water system may be managed by either a local health department or the state health department.

- **School capacity**

Contact the local school board to identify any concerns with regard to the new development. If capacity exists for anticipated increase in students, a formal letter may be required as a condition for approval.



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C. *Physical Constraints*

- **Topography and stormwater management**

With either general guidelines from the developer or an already approved preliminary plan in hand, the site visit is a vital next step. Upon visiting the site, which could be 10 acres or 100 acres, the engineer should observe the terrain. If the site is heavily wooded with tangled masses of vines, then obviously it may not be expedient to walk the site. Photogrammetry is a valuable source of topographic information for those types of sites and may best be accomplished after the leaves have fallen. A very simple definition of photogrammetry would be the measurement of distance and elevation using aerial photographs. LIDAR (Light Detection and Ranging) is another aerial method using laser pulses to measure elevation. Survey professionals are the best source for this information.

In observing the terrain, look for drainage patterns and low points for possible stormwater management device (retention ponds) locations. If an approved preliminary plan exists, compare the proposed location of any ponds to the existing terrain for any potential conflicts.

USGS (United States Geological Survey) topographic maps, like the one shown in **Figure 3**, can be helpful in identifying off site drainage that may impact the project site. They also help identify nearby streams, which will determine specific watershed requirements.



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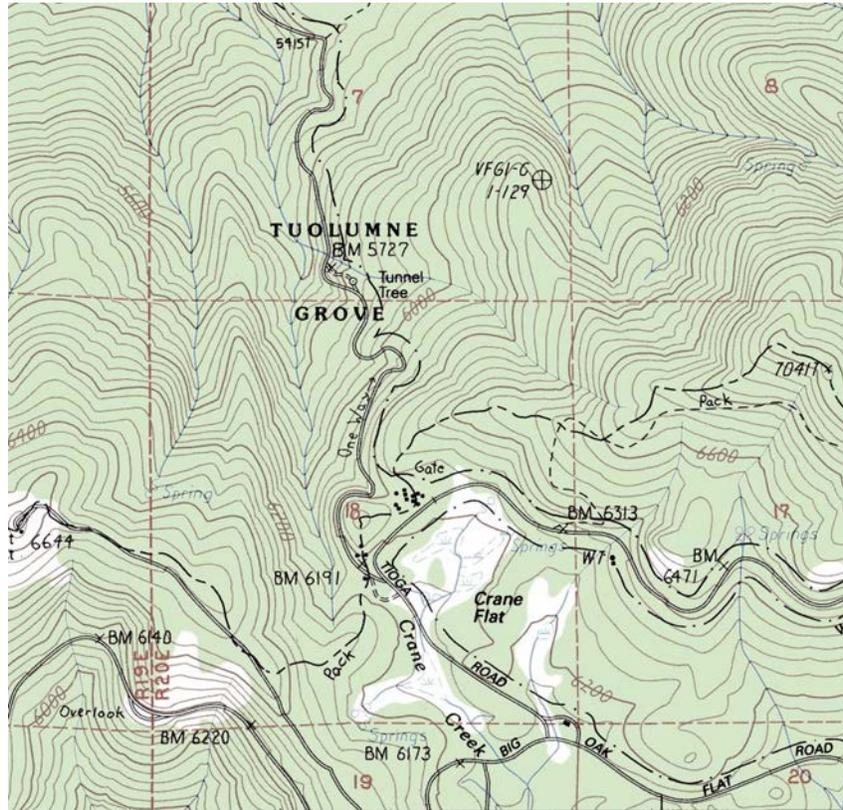


Figure 3. USGS Topographic map. Accessed Apr. 2, 2018 from:
<https://commons.wikimedia.org/w/index.php?curid=4021677>

- **Topography and Sewerage**

If the project site is in an area of low elevation, say for instance, the coastal plains, gravity sewer is usually not feasible. It is probable that some sort of force main and one or more lift stations would be required. This is assuming that the sites would not be served by septic tanks and drainfields. A force main is a pressurized sewer line. A lift station is an underground pump that lifts the wastewater from a lower elevation to a higher elevation. The site visit would be a good time to note the location of any nearby sanitary sewer manholes. Some engineers, with the right tools and safety awareness, remove



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the sewer manhole cover and measure the depth of the bottom of the inside of the pipes in these manholes. This elevation is called the invert. Of course, the surveyor will be providing an exact elevation but if it is obviously shallow in comparison to the future development then this is something to resolve early on when considering sewer design options. The viability, in terms of capacity or condition, of any sanitary sewer tie-in point will also need to be verified with the local utility department.

Rolling and steep terrain are not necessarily exempt from needing force mains or lift stations. Sometimes there are obstructions which interfere with gravity flow, or perhaps the only available sewer line route will cause excessively deep sewer lines. Maybe the only existing tie-in point is higher in elevation than the proposed sewer outlet point. There are times when the proposed sewer will have to be extended quite a distance off of the development. So, survey information will be needed for the off-site areas as well. There is also a possibility that the proposed sewer would need to pass through private property. As was previously mentioned in the planning discussion; easements, permission and possible compensation would be required for this.



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- **Topography and sight distance**



Figure 4. Example of limited sight distance.

Topography affects sight distance. Sight distance, simply put, is how far one can see from a particular vantage point. As **Figure 4** shows, a person driving up this hill would not be able to see a golf cart, for example, crossing on the other side of the summit until he or she were at nearly the top of the summit. This would be vertical sight distance. Horizontal sight distance comes into play when there are horizontal curves in the roadway, which again limit the ability for drivers to see upcoming obstructions. These limiting parameters are defined as stopping sight distance. **Stopping sight distance** is the distance that the driver needs to bring the vehicle to a stop so as to avoid



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hitting an obstruction. The state department of transportation is usually the source of these requirements. Height of eye of the driver, height of the potential obstruction, steepness or grades of vertical curves, radii of horizontal curves, and speed limits are factors used to determine stopping sight distance.

If there is a preliminary plan already approved, the site visit would be an ideal time to verify if the proposed entrance location is appropriate from a sight distance perspective; this is considered examining **intersection sight distance**. An intersection sight distance diagram is shown in the design elements section. One may roughly estimate from a scaled plan where the proposed entrance is located along the existing intersecting road. If one positions oneself at that location, as if one were waiting at a stop sign and looks left and right, it will be obvious if sight distance may be an issue; both horizontally (sharp curves) or vertically (steep hills). Naturally, the survey will provide exact distance and elevation information but by examining it ahead of time, certain spots can immediately be ruled out. Since the required minimum sight distances are a function of the design speed limit, observe the posted speed limit of the existing roads adjacent to the project parcel. Note that design speed limit and posted speed limit are not the same.

- **Topography and safety**

Steep rolling terrain or ravines on the proposed site can present a challenge not only in terms of sight distance but in terms of steep driveways and sidewalk ADA (Americans with Disabilities Act) accessibility. Costs are always a concern; however, saving cut and fill costs can sometimes lead to extremely inconvenient driveways and walks. For some residents, they may prove unmanageable. **Figure 5** helps remind us of various activities that could be risky if drives and walks are too steep, such as putting a heavy trash receptacle at the curb or trying to park a stroller next to the garage.



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Figure 5. Example of steep driveway with no landing.

- **Topography and layout**

An advantage of visiting the site is that it helps visualize what options exist in terms of amenity location and street layout. One may identify attractive view areas or good locations for playgrounds. Seeing the big picture with the panorama of the surrounding area will help guide your layout choices.

While on the site, other items to note on a preliminary plan or sketch are; streams, ponds, marshy areas, power poles, transmission lines, gas line indicators, cable or telephone lines, water valves or hydrants, storm and



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sanitary sewer pipes or manholes, unusual formations, tanks, stains, debris piles, etc. While it is true that all of this information will be shown on the survey map it is still a good idea to note items and photograph the site. Video and drone technology may be feasible for some firms.

III.Design Elements

A. Existing Conditions Survey

A physical survey forms the indispensable basis and background of most of the construction plan sheets. It shows the property lines, overall topography and other existing features. For larger parcels this may be done by photogrammetry or for smaller parcels this may be an actual ground survey. The existing street at the new subdivision entrance(s) will need a detailed ground survey with numerous existing spot elevations labeled so that the entrance and any required road widening can be graded properly.

B. Layout Plan

The following layout elements are typically found in the municipality's design standards manual or the state's department of transportation and most are shown on the layout plan. A few of these requirements may also be a matter of case-by-case policy and should be confirmed through meetings with the city staff. Pertinent dimensions should be labeled.

- Minimum lot widths and areas
- Setbacks - front, side and rear yard
- Cul-de-sacs - minimum radius – maximum street length
- Traffic calming - speed bumps
- Future connection requirements
- Stopping sight distance requirements–vertical and horizontal
- Intersection Sight Distance - some municipalities require a sight distance triangle to be depicted, see **Figure 6**.



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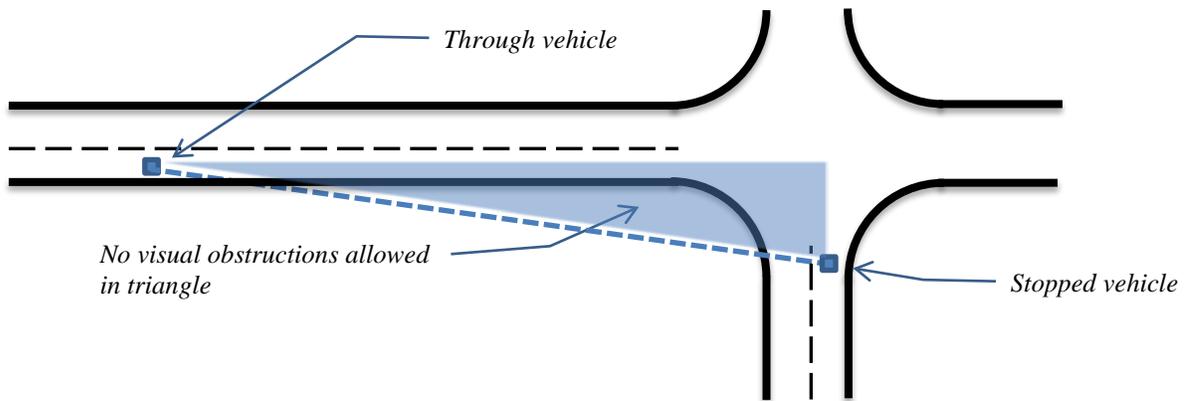


Figure 6. Basic intersection sight distance triangle.

- Right and left turn, deceleration lane requirements
- Easements such as water, sewer, cable, telephone, gas
- Street naming requirements
- Public and Private street standards (min. width and typical pavement cross-section)
- Guardhouse standards for private developments
- Entrance signs
- Striping
- Stop signs, crosswalks
- ADA sidewalk ramps



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C. Grading Plan

A grading plan shows the existing topography, usually shown as dashed and faded lines in the background and the proposed topography or elevation contours as solid and bolder. The contours are shown at 1' or 2' intervals usually, supplemented with sufficient labeled spot elevations to assist with construction of various items. The local subdivision ordinance or the design manual should contain the requirements. Some items to consider when doing a grading plan are as follows:

- Are overlot grading plans allowed or required or are detailed grading plans required (for lot sites)?
- Consider walk-out basements for front to back sloping lots.
- Consider placing garage on high side for steeper side to side sloping lots (reduces steps in garages).
- In ground basements; consider drainage patterns and sewer issues
- Cut-Fill – minimize by attempting to grade as close as possible to existing terrain.
- Maximum yard and ditch slopes (usually 3:1 or 4:1). As a simple reminder: a 3:1, or 3 to 1 slope means that for every 3 feet of horizontal distance there is a 1 foot drop or rise in vertical elevation.
- What are maximum street grades? (as high as 15% or more in mountainous areas); however, try to provide landings at intersections.
- Minimize drainage across lots from side to side, grade lots to drain to front or back using swales between yards. Reminder: consider if solid fences will be allowed in subdivision as they may impede flow of swales.
- Prevent water from draining across intersections
- Grade yards to drain water away from buildings.
- Avoid steep driveways; at least provide landings in front of garages.



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D. Drainage Plan

The drainage plan works hand in hand with the grading plan. All of the storm pipes, storm manholes, inlets and stormwater management devices are depicted on the drainage plans. The local drainage design manual should have all of the necessary design standards. Typical required items (with appropriate descriptions and dimensions) are as follows:

- Curb inlets
- Yard inlets
- Storm sewer piping
- Storm sewer manholes
- Stormwater retention or detention ponds, including pond access roads and easements
- LID features such as infiltration basins or bioswales
- 100-year Overland relief – This may or may not be required but even if not required it is prudent to examine and delineate the path and elevation of water in relation to nearby buildings, should the stormwater management devices become clogged during a 100-year storm event. Consult the applicable drainage manual for details.
- Adequate outfall – This is the location where the end of storm sewer system empties or outfalls. Sometimes cross sections of the receiving swale, ditch or stream are required to be shown on the plan with accompanying calculations. The calculations are to demonstrate that the water draining into the receiving channel will not erode the banks nor overtop the channel.

E. Erosion Plan

The erosion plan shows all the required erosion control measures with adequate descriptions and dimensions. A state erosion control manual or a municipality's erosion control manual has minimum standards and details. Sometimes separate calculations are required for certain items. Typical items are:



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- Sediment basins and/or silt traps. Often sediment basins are allowed to be converted to retention ponds. Confirm this with the reviewing jurisdiction.
- Inlet protection
- Silt fence
- Diversion berms
- Straw mulching
- Temporary seeding
- Construction entrance

F. Utility Plan

The utility plan sometimes combines water and sewer into one plan. Usually a profile of the pipe systems is required to be shown on “plan and profile” sheets. A profile (see **Figure 7**) is basically a cross-section of the street or ground showing the vertical and horizontal position of the pipes. It is helpful in visually identifying minimum cover over pipes and vertical separation requirements between different pipes. Some plan elements are:

- Water lines & easements

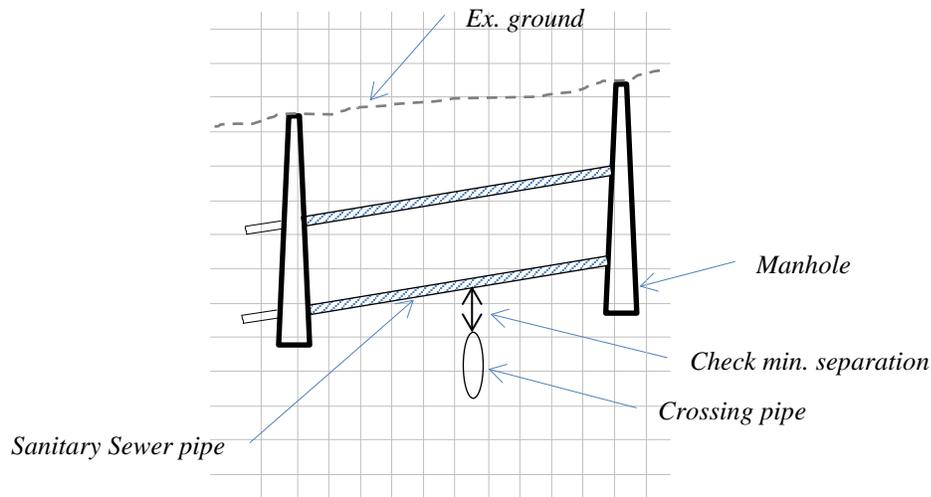


Figure 7. Simplified profile showing crossing pipe. (Not to Scale)



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- Fire hydrants
- Water meters
- Shut-off and blow-off valves
- Water wells
- Sanitary sewer lines, laterals and cleanouts, easements
- Sanitary sewer manholes
- Septic tanks and drainfields (including alternate drainfields)
- Cable, telephone and/or electric easements
- Street light locations

G. Landscape Plan

Depending on the municipality, the landscape plan may be fairly minimal or it may be quite detailed with plant tables, schedules, details, open space and tree coverage calculations, and irrigation details. The landscape plan may require the signature of a registered landscape architect. An average level of detail might show the following:

- Larger “street” trees along streets, types and sizes
- Smaller trees along grass strips or medians, types and sizes
- Shrubs at entrances and medians, types and sizes
- Sodding, permanent seeding or mulching for all disturbed ground
- Special landscaping for wet ponds and constructed wetlands

H. Detail Sheets

The detail sheets will encompass all of the necessary details of the design components of the plan. These details will show types, materials, dimensions and cross sections so that the items can be constructed properly and according to the design standards. Many public works departments have pdf’s or CAD (computer aided design) drawings that may



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be copied into the project plan. Some will only allow their drawings to be utilized. A partial listing of typical details is listed below:

- Pavement cross-sections
- Street cross-sections
- Curb and gutter
- Sidewalk
- ADA ramp
- Storm inlet and manhole details
- Pond or other stormwater management device details
- Silt fence
- Sediment trap
- Slope stabilization
- Construction entrance
- Fire hydrant
- Water valve
- Water service connection
- Sanitary sewer manhole
- Sanitary lateral connection
- Sanitary sewer cleanout
- Tree planting
- Seeding schedules



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IV. Conclusion

The subdivision development process described in this course, separates the planning elements from the design elements. It is important to identify the planning elements, for two reasons; first, issues which may stall or even stop the development need to be brought to light early on and secondly, limitations to the overall buildable are made evident. Doing things in the proper order and will reduce unnecessary delays and will help clarify expectations of all those involved in the development process.