Stormwater Management Master Plan For Davis County, Utah

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A Case History in 208 Water Quality Management Planning

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STORMWATER MANAGEMENT MASTER PLAN FOR DAVIS COUNTY, UTAH

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STORMWATER MANAGEMENT MASTER PLAN
FOR DAVIS COUNTY, UTAH

The areawide water quality planning program for the tri-county planning area of Weber River Water Quality Planning Council (WRWQPC) was initiated in June, 1975. A major effort of the WRWQPC was directed toward documenting stormwater runoff problems, assessing the capacity of stormwater facilities, identifying water quality related problems and developing a master plan to correct these problems. This urban stormwater runoff study focused on the highly developed Davis and Weber Counties. Morgan County is and will continue to be a rural area, relatively unaffected by urban runoff. Growth in Davis and Weber Counties has increased significantly over the last decade. Davis County, located immediately north of Salt Lake City, is one of the fastest growing areas of the State and population is expected to increase from a 1975 level of 115,050 to 227,800 by 1995.

The already rapid growth of the planning area, coupled with increased development, has resulted in significant problems with stormwater runoff. WRWQPC's stormwater master plans address the alleviation of flooding and the design modification of conventional detention basins to control water quality impacts of urban stormwater runoff. These plans have now been adopted by Davis and Weber Counties.

Davis County is currently implementing its program through a recently adopted County-wide ordinance. All sixteen municipalities in Davis County have, by interlocal agreement, set maximum runoff limits and other requirements for new development and established Davis County as the stormwater management agency. Weber County is expected to implement a similar if not an identical ordinance in the near future. This study will, however, only focus on Davis County's experience.

BACKGROUND

The tri-county area of the Weber River Water Quality Planning Council (WRWQPC) is shown in Figure 1. Bordered on the east by the Wasatch Range which slopes westward to the Great Salt Lake, the area has experienced flooding problems as the result of the terrain and dense urban development. The objectives in initiating the study of urban stormwater problems were to determine the most cost-effective urban runoff flood control methods and to provide alternatives which would also address water quality. The flooding problem in Davis and Weber Counties has become significant over the last decade as development, with the resultant increase in impervious surfaces, has occurred. Prior to development, the natural terrain and vegetation impeded runoff. Natural channels were able to accommodate the stormwater flow but now with increased development in addition to alteration or elimination of some of the natural channels, the increased quantity and velocity of storm runoff has caused major flooding problems.

Urban development is concentrated along the foothills and the lower, gently sloping areas between the Wasatch Mountains and the Great Salt Lake. Development on the foothills is on steeply sloped areas and, consequently, streets running perpendicular to the foothills carry a large volume of stormwater toward the lower slopes. The drainage channels in the intermediate slope area (which contains the majority of development

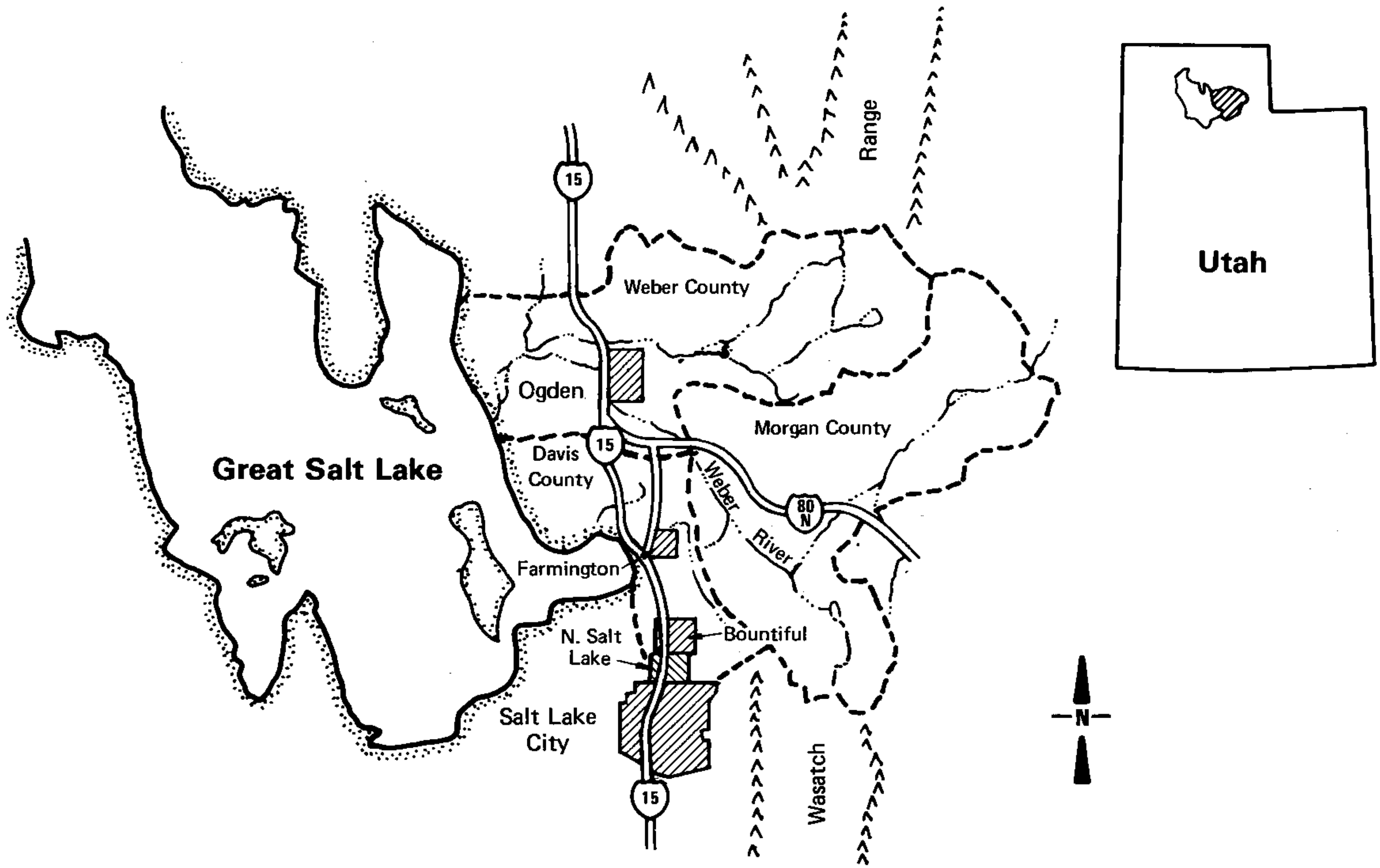

Figure 1. Weber River Water Quality Planning Region.

and streets) have a much smaller carrying capacity than the steep slopes, thereby making it difficult to provide sufficient drainage onto the extremely flat area along the shore of the Great Salt Lake.

PROJECTING STORMWATER FLOWS

In developing the stormwater master plan it was first necessary to characterize the volume of runoff which needed to be controlled to prevent flooding. Significant runoff in the Weber River comes from two sources, snowmelt and cloudbursts. The runoff produced from melting snows in the mountains lasts for several weeks in the late spring. Because of the large volume of snowmelt, it was not considered feasible to control this flow by structural methods. Cloudbursts generally occur during the summer and early fall and produce frequent, high intensity, short duration runoff events. Peak flow is considerably higher than snowmelt flow and cannot be carried in the existing channels.

A study of typical drainage areas in Davis and Weber Counties indicated that the average instantaneous runoff from natural undeveloped surfaces is approximately 0.20 cubic feet per second (cfs) per acre (0.014 cubic meters per second per hectare - m^3/sec/ha). Runoff from highly developed areas was found to be several times larger.

For each of 180 drainage areas in Davis County, the peak runoff flow was calculated based upon drainage area characteristics. The maximum rainfall intensity figure was derived from a storm event which would occur once every 10 years. Once peak flow was calculated, it was compared to the average runoff value of 0.20 cfs/ac (0.014 m^3/sec/ha) for the drainage area without development. This comparison indicated the severity of the excess stormwater runoff. An example of the calculations of estimated runoff flows for selected drainages is shown in Table 1. The last column indicates the excess runoff in these areas.

ALTERNATIVE CONTROL METHODS

In assessing alternative methods to control excessive flows and flooding caused by urban stormwater runoff, six basic control alternatives were considered and evaluated. These controls, as depicted in Figure 2, were developed for their relevance to Davis County and included many major considerations as detailed in WRWQPC's basic planning document, "An Inventory of Nonpoint Pollution Control Strategies."

The alternative of providing no storm drainage facilities for urban areas was determined to be unacceptable because of the potential for property damage and loss of life. The construction of storm drains for peak flow was also considered unacceptable because of the high cost of installing the large diameter pipe needed to accommodate the high peak flow from cloudbursts.

The use of centralized, on-site detention basins was assessed as a favorable, cost-effective method for controlling urban stormwater runoff. With the use of detention, runoff flows would be significantly reduced. Even short term detention allows greatly reduced conveyance facilities which in turn greatly reduce costs, often to a point where local governments are able to finance these projects.

Detention basins for storing the entire volume of water from a particular storm were assessed as impractical in urbanized areas because of the large storage area required. Additionally, the retention basin would generally be limited to single purpose use.

A canal-like drain was considered as another practical means of accommodating excessive surface runoff as well as providing detention and subsurface drainage for areas with a high water table. The existing Davis-Weber Canal could be modified to serve this purpose.

UTILITY OF DETENTION BASINS

The use of both centralized and on-site detention basins was determined to be advantageous for several reasons. First, storm runoff flows could be reduced to about 10 percent of their peak values which means a significant reduction in the size of conveyance facilities. Second, because the flow would be detained (rather than retained for long periods), de-

Table 1. — Storm runoff estimates for selected drainage areas in Davis County, Utah.

Drainage no. (total acres) total hectares	Land use 1975	Area %	Runoff coeff.	Weighted coeff.	Time of concen-tration (min)	Rainfall intensity (in/hr) cm/hr	Peak runoff flow (cfs) m^3/s	Total storm runoff volume (ac/ft) m^3	Runoff flow at (0.2 cfs/ac) $0.014 m^3/s/ha$	Excess runoff flow (cfs) m^3/s
#54 (260 ac) 108 ha	Low den. residential Agricultural Undeveloped	20 20 60	.4 .3 .25	.29	25	(1.6) 4.1	(121) 3.4	(5.2) 6414	(52) 1.5	(69) 1.9
#55 (180 ac) 73 ha	Low den. residential Agricultural Undeveloped	20 10 70	.4 .3 .25	.29	25	(1.6) 4.1	(82) 2.3	(3.4) 4194	(36) 1.0	(46) 1.3
#56 (60 ac) 24 ha	Low den. residential Commercial	90 10	.3 .8	.35	16	(2.0) 5.1	(42) 1.2	(1.3) 1603	(12) 0.3	(30) 0.9
#57 (100 ac) 40 ha	Low den. residential Agricultural High den. residential	20 60 20	.2 .1 .4	.18	32	(1.4) 3.6	(25) 0.7	(1.5) 1850	(20) 0.6	(5) 0.1
#58 (240 ac) 97 ha	Agricultural Low den. residential Light industrial	90 5 5	.1 .2 .2	.11	65	(0.8) 2.0	(21) 0.6	(2.1) 2590	(48) 1.3	– –

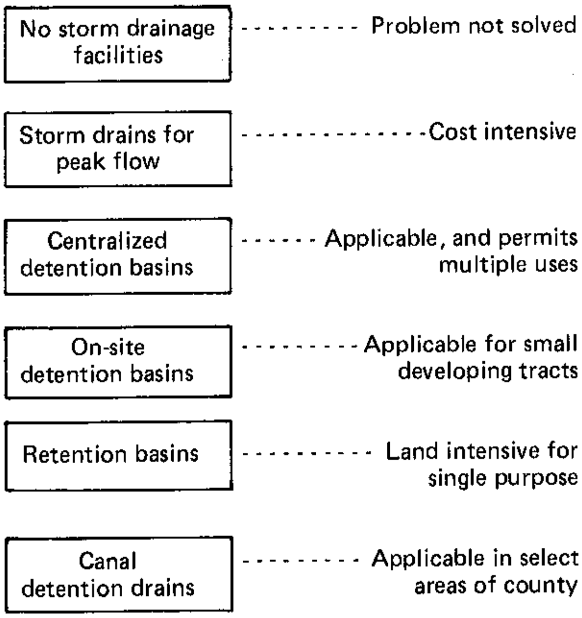

Figure 2. Alternative stormwater control methods.

tention basins could serve as multiple use facilities such as parks and open space when they were not being utilized for detention. The cost of cleaning a detention basin to allow for continued park use was determined to be far less than the cost of providing a stormwater collection system for the peak runoff.

In addition to concluding that large, centralized detention basins and smaller, on-site detention basins for individual developments were the most effective means of controlling existing and future storm runoff problems, the WRWQPC and its consulting engineers recommended a maximum runoff limit. This criterion was established as 0.20 cfs per acre (0.014 m^3/s/ha) and represents runoff from a naturally vegetated, gently sloping area that has no development. Because development increases runoff, it was determined that the developer should provide on-site runoff detention, limiting runoff to the pre-development flow. The advantages of using a standard maximum runoff rate of 0.20 cfs per acre (0.014 m^3/s/ha) were:

- Runoff from areas to be developed can be calculated prior to actual development, thereby facilitating minimum design and installation of culverts, bridges, and other drainage facilities in and around the proposed development, i.e., assuming snowmelt is projected as less than this peak flow.

- Design capacity for any drainage control can be easily approximated by multiplying the drainage area by 0.20 cfs (0.0056 m^3/s).

- Storm drainage construction costs will be reduced in many cases with less peak flow to consider in design analysis.

- Controversy between municipalities would be avoided because both would be operating under the same uniform design criterion.

INCORPORATING WATER QUALITY CONSIDERATIONS IN STORMWATER MANAGEMENT

The development of potential control methods was predicated on an assessment of variables which affect the general quantity and quality of urban stormwater runoff in the Davis County area. Although no Utah standards or criteria for water quality problems caused by stormwater exist, three considerations for analyzing urban wasteloads were studied.

- Average yearly storm pollutant load

- Average pollutant load, within an event

- Variation of pollutant load within an event

A determination of the average yearly storm pollutant load is based on the assumption of consistent storm flows and pollutant loads. Such predictions are useful in an area where storm events occur frequently and are of long duration, but this is not the case in Davis County. The second consideration indicates the variability of average pollutant loads from event to event, while the third is indicative of the variability of pollutant loads in a single event.

Because rainfall in the area is characterized by high-intensity, short-duration storm events during the summer season, pollutant loads were believed most significant within a single event. This set of conditions caused WRWQPC to focus on the loading encountered during the initial or "first-flush" washout of pollution during each storm.

The typical storm event selected for pollutant load analysis had an intensity of 20 percent of the once-in-10-year storm event. This storm normally occurs a maximum of five times during the summer season. Since these storms also occur during the summer at the time of lowest stream flow, it was concluded that summertime first-flush controls would be the most effective in reducing pollutant loads.

In developing alternatives to control or reduce the pollutant loadings of summertime first-flush, three primary control techniques were investigated: source controls, collection systems controls, and storage and treatment. These control methods were evaluated in terms of the efficiency of removal, relative costs, and applicability to the study area. Table 2 summarizes the conclusions regarding efficiency of each control measure in reducing those pollutants studied. It is noted that physical treatment processes are the most effective, but as one might expect, they are also the most expensive. Physical treatment requires collection; however, no stormwater collection system or combined sewers are in use in Davis or Weber County. Therefore, the WRWQPC concluded that the prohibitive cost of collection alone made source controls the more cost-effective solution. As discussed earlier, detention basins were assessed as the most desirable method of source control.

In addition to looking at detention basins as source controls to reduce the quantity and improve the quality of urban runoff, other structural and nonstructural source control methods were reviewed. Structural alternatives included the following:

POROUS PAVEMENT. The use of porous pavement enhances groundwater recharge, eliminates the need and associated costs for curb and gutter, and reduces runoff velocity from pavement surfaces.

PARKING LOT PONDING. Temporary ponding of water on parking lots provides a slow runoff rate and because of the low use rate of parking lots in the area for most of the year, the public would not be greatly inconvenienced.

INFILTRATION SYSTEMS. Such systems consist of excavated holes in the ground filled with coarse stone or concrete block with perforations. Infiltration systems can be used in areas where limited detention capacity is required.

DIVERSION STRUCTURES. These structures have been used to a large extent along major highways as a means of diverting runoff. They are useful in some areas but should not be used on sites where the potential exists for slumping or landslides.

ROOFTOP PONDING. Stormwater may be stored on rooftops equipped with detention drains. In many cases, buildings in the area are already designed to support this additional load.

Non-structural control methods which could reduce pollutant loads from stormwater discharges were also assessed and included the following:

OPEN STORAGE REGULATIONS. Restrictions on open storage of pesticides, oil and lubricants, paper, solid wastes, etc. for industrial and commercial enterprises not affected by existing Federal regulation of oil and hazardous materials.

ANTI-LITTER LAWS. Provisions for sidewalk containers and clean-up requirements for concentrations of litter at refuse dumping sites, vacant lots, parking areas, drive-in restaurants, etc.

AIR POLLUTION ABATEMENT. Active enforcement of air pollution regulations to reduce particulate fallout.

CATCH BASIN CLEANING. Regular maintenance and cleaning of catch basins.

Table 2.—Pollutant removal efficiencies for urban runoff control strategies.

Strategy	BOD reduction				Susp. solids reduction				Total coliform reduction				Nutrient reduction			
	0 to 25%	25% to 50%	50% to 75%	75% to 100%	0 to 25%	25% to 50%	50% to 75%	75% to 100%	0 to 25%	25% to 50%	50% to 75%	75% to 100%	0 to 25%	25% to 50%	50% to 75%	75% to 100%
Source controls																
Erosion control	x					x			x				x			
Detention basins	x				x				x				x			
Retention controls				x				x				x				x
Collection system controls																
Sewer separation (w/discharge to receiving stream)	x				x				x				x			
Sewer separation (w/discharge to treatment)		x				x					x			x		
Storage & treatment																
Storage	x					x			x				x			
Physical treatment																
Sedimentation		x					x		x				x			
Screening		x						x	x					x		
Flotation			x					x				x			x	
Filtration		x					x		x				x			
Disinfection	x				x							x	x			

IMPROVED DE-ICING METHODS. Operator's training and efficient equipment to provide optimum spreading of appropriate sandsalt mixtures. (De-icing salts which contain cyanide or chromium compounds as anti-caking or corrosion inhibitors should be prohibited.)

PUBLIC EDUCATION. Educational programs to inform citizens of good housekeeping measures and encourage sponsorship of clean-up campaigns.

STREET CLEANING. Street cleaning programs with vacuum sweepers to reduce the pollutant load in urban runoff (provided streets are cleaned often enough to limit first-flush effects).

LAND MANAGEMENT. New development controls, such as erosion and sediment ordinances, zoning, building codes, and related regulatory measures.

DETENTION BASIN DESIGN AND WATER QUALITY CONSIDERATIONS

The positive aspects of detention basins for flood control have been outlined previously. Emphasis in the past has been oriented toward improving water quality strictly by flow attenuation and no consideration has been given to the design of basins as "treatment" facilities.

Detention basins by nature of their design will afford some pollutant removal due to settling. The WRWQPC and their consultants felt that if this settling were to occur in a controlled portion of the basin, the maintenance problem could be greatly reduced and a more predictable improvement in water quality could be realized.

Difficulty has been experienced in accurately predicting the pollutant removal capability of detention basins as they are presently designed. Many variables are involved including basin volume, depth, shape, flow patterns in the basin, and inlet-outlet configuration. In addition, the pollutant load introduced into the basin is highly variable. Of prime concern is the first-flush phenomenon. It was known that in many urban drainage situations, a large fraction of the total pollutant loading is encountered during the early stages of runoff. This occurs because a disproportionately high fraction of the runoff load, which consists of materials accumulated on land surfaces and in storm drains between rainfall events, is carried in the first portion of the runoff. As the storm continues, the relatively high pollutant concentration which existed during the early runoff stages diminishes throughout the duration of the storm. Factors which affect the magnitude of the first flush are land use and size of the drainage basin, length and intensity of the storm, and overall, the time intervals between the flushing action of each sub-basin.

The settleable solids are the only portion of the total solids in the runoff which can be removed to any extent by detention basins. These solids are normally 10 or more microns in diameter. Non-settling solids are normally 1 to 10 microns in diameter. The settling velocity for settleable particles, at 10°C, ranges from 1000 to 63 millimeters per second for gravel and sands to less than 0.025 millimeters per second for fine silt. Since the majority of the pollutant load is associated with sands and silt, detention basin design must remove as many of these particles as possible.

A standard detention basin design is shown in Figure 3. A typical settling pattern for this type of basin is shown in Figure 4. As can be seen, none of the flow of solids goes into the basin during the first hour. This first flush, which contains the peak pollutant concentration, goes past the basin without entering the detention basin.

A modified detention basin design is shown in Figure 5. This design provides a chamber through which all runoff would flow regardless of the size of the storm. The chamber incorporates a smaller exit pipe or weir to permit buildup of settleable solids in the chamber and includes a skimmer to collect "floatables" that would be retained on the water surface. The chamber would be cleaned periodically in much the same way as a catch basin. This modification could, with a combined cleanout grate and hydraulic overload safety valve

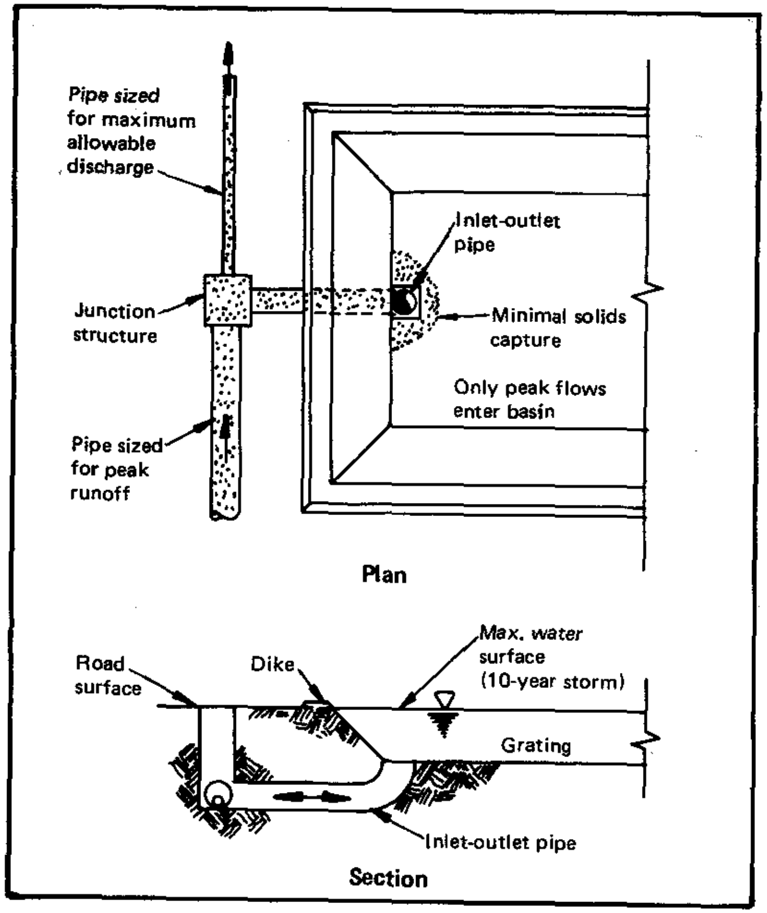

Figure 3. Conventional detention basin design.

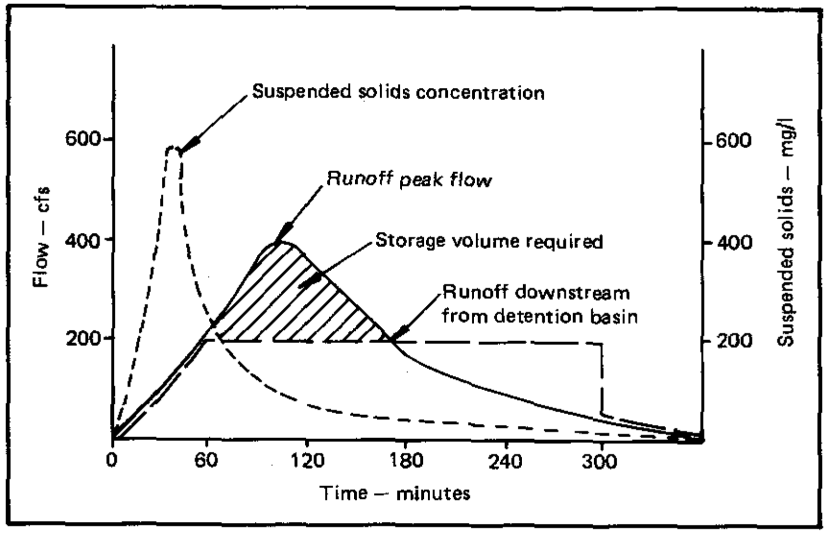

Figure 4. Conventional detention basin settling pattern.

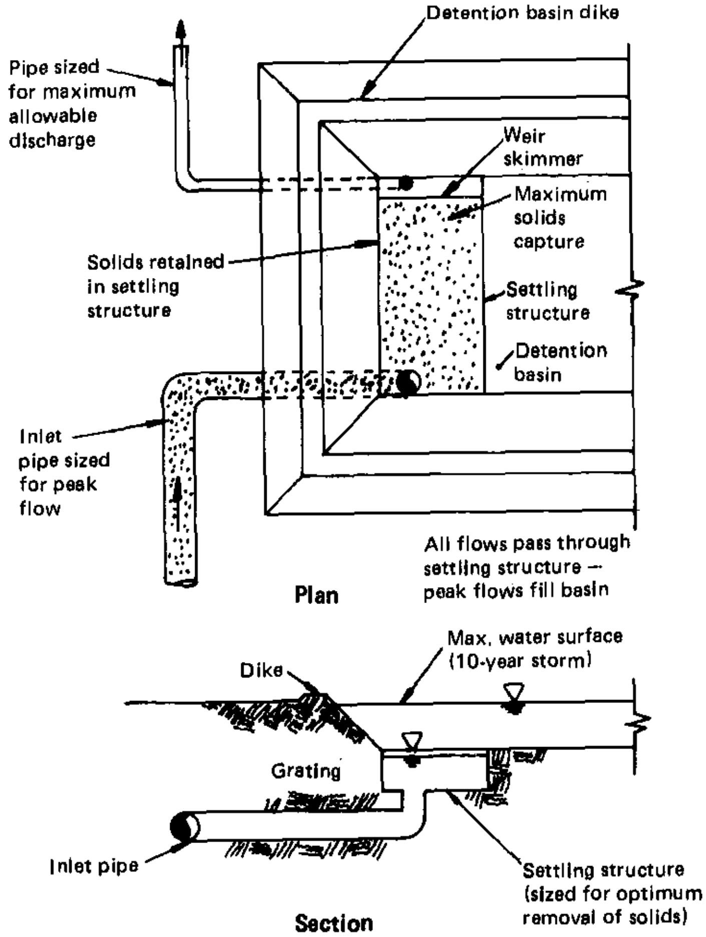

Figure 5. Modified detention basin design.

(not shown), simplify the maintenance inherent with detention basins and would also enhance the water quality. Flow attenuation would be realized while at the same time a portion of the pollutant load would be removed. A detention basin may reduce suspended solids and biochemical oxygen demand by 50 to 75 percent and nutrients and coliform bacteria up to 25 percent.

URBAN STORMWATER MASTER PLAN

The groundwork for acceptance of the Stormwater Master Plan by the tri-county area was established early in the WRWQPC water quality planning efforts. In Davis County, public and governmental meetings with the County and with the sixteen municipal units within the County greatly facilitated subsequent implementation of the plan. As data was assembled for projected stormwater flows, pollutant loads, control methods, and design of necessary drainage projects, this information was shared with the planning and regulatory agencies in county and municipal governments. By maintaining ongoing communication among the affected parties, the WRWQPC's recommended plan for stormwater management was well understood and the need for control was well established.

To provide a uniform and coordinated county-wide approach to implement the Stormwater Management Plan, two basic management agency approaches for Davis County were studied.

- County government as the management agency. Create a flood control fund with the use of a county-wide property tax, having the County manage major flood control projects with City cooperation.

- Special improvement district for flood control. Create a special improvement district to levy a property tax and provide funding to handle major flood control projects.

The special improvement district has the organizational advantage of providing a separate governmental entity devoted exclusively to flood control. The creation of a new and separate agency would, however, be a difficult approach politically. Also, such an agency would not have authority for land use planning and development regulations or the broad powers of county or municipal government to further alleviate runoff problems through planning mechanisms.

An advantage of a county management agency is that Davis County has under Utah law the authority over stream channels for both incorporated and unincorporated municipalities. It may levy all necessary flood control taxes on property in the county. It also has authority, with voter approval, to issue bonds for capital improvements. In addition, the county government may use planning and zoning powers to pass ordinances regulating development, thereby decreasing the urban runoff problem, especially in unincorporated areas, and can develop common ordinances which the municipalities may adopt on a cooperative basis. Because of the many advantages and its political acceptability, Davis County was selected as the management agency for the implementation of the Stormwater Management Master Plan.

The Davis County Commissioners have willingly accepted the responsibility as the management agency. A committee has been established to set drainage project priorities for the County and the stormwater runoff control ordinance for new development has been adopted. A $500,000 fund has been established to carry out the first year's operation and to implement high priority drainage projects.

The stormwater runoff ordinance adopted by the County sets the maximum runoff standard at 0.20 cfs per acre (0.014 $m^3/s/ha$) and requires developers to construct the necessary detention facilities to store excess runoff. In addition, the ordinance enables the County, as the management agency, to assess a fee on the developer for construction of any additional County stormwater facilities which would be needed due to the development. The fee would be seven percent of the fair market value of the unimproved real estate. This was a major step in improving water quality in Davis County.

The WRWQPC plan for stormwater runoff management in Davis County has been adopted. The Davis County program, complete with a stormwater ordinance and management structure, is now operational. With the acceptance of a similar stormwater ordinance and management arrangement by Weber County, both of these rapidly growing areas will improve drainage *and* water quality through the comprehensive areawide planning process.

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