SECTION 6.1

INTRODUCTION

The East Clayton Neighbourhood comprises the southeastern sector of the Clayton Neighbourhood and is approximately 250 ha in land coverage. The area is bounded by 196 Street to the east (the east/west boundary between the City of Surrey and Township of Langley); to the north by 72 Avenue; to the west by 188 St.; and to the south by Fraser Highway and 64 Avenue.

The East Clayton Engineering Servicing Plan has been developed to support the land use proposed in the East Clayton Neighbourhood Concept Plan (NCP). The East Clayton NCP as presented in the preceding sections describes the planned land use and design guidelines for this neighbourhood. The following section describes the engineering servicing plan.

In context, the East Clayton Servicing Plan presents a more refined servicing concept for this area and follows the Clayton Generalized Neighbourhood Concept Plan (GNCP), the Master Drainage Plan (MDP) and supporting Engineering Servicing Plan completed in 1998.

Furthermore, this servicing plan includes innovative servicing standards resulting from an extensive interactive effort to implement a more environmentally sustainable development concept in East Clayton.

The servicing concept requires detailed design and refinement of standards as the development applications progress through the approval process. The City will need to ensure that the performance standards of this development plan are achieved during the development approval and implementation process. To facilitate that, there will need to be increased effort to engineer the design standards as the initial development is being designed.

SECTION 6.2

6.2.1 Background

The transportation servicing plan for East Clayton was developed between 1996 and 1999, as part of:

- the studies and public process carried out for the Clayton Generalized Neighbourhood Concept Plan (GNCP); and,
- the Charette and public meetings held as part of the East Clayton Neighbourhood Concept Plan (NCP) process.

A series of reports documenting the development of the transportation servicing plan were submitted to the City of Surrey over the above time period; these are listed in ***Appendix A.1***

6.2.2 East Clayton Road Network Plan

6.2.2.1 Context

The basis for the development of the detailed East Clayton Road Network Plan was the May, 1999 version of the GNCP Major Road Network Plan approved by City Council as part of the Stage 1 Plan for the whole Clayton area, shown on ***Figure 6.2.1***. This plan represents the "ultimate" road network plan at full build-out of Clayton as well as the Willoughby area in the Township of Langley. Similarly, ***Figure 6.2.2***, the recommended Clayton GNCP Bicycle Network Plan was used as the basis for the development of the East Clayton NCP Bicycle Network Plan.

6.2.2.2 Recommended East Clayton Road Hierarchy and Network Plan

In keeping with the sustainability objectives for the East Clayton area, the East Clayton Road Network Plan was developed during the multi-stakeholder Charette process and was based upon the following key principles:

- Maintaining the Arterial and Major Collector road network as defined in the Clayton GNCP, as much as possible;
- Use of a modified "grid" system of local and minor collector streets, with short blocks and rear lanes where possible, to provide multiple route choices, and a more refined pedestrian/cyclist network;

- Provision of a richer “menu” of street cross sections to respond to different land uses and functions intended for various streets;

- Respect for the continuity of green space, drainage requirements and land use/topography conflicts, as well as existing property boundaries;

- Incorporation of alternative street and boulevard drainage systems which reduce environmental impacts of urban development, by promoting in-ground disposal of stormwater using infiltration techniques and measures;

- Emphasis on street trees as a key component of the City’s “urban forest” policies.

Table 6.2.1 below summarizes the recommended street hierarchy system. It shows the various right-of-way and pavement widths associated with each street type.

***Table 6.2.1*: Street Hierarchy System for East Clayton**

No.	**Type**				**RoW Width**	**Paved Width [1]**	**Cross Section Code [2]**
1	ARTERIALS	MAJOR	PARKWAY	ULTIMATE 4 LANES	27.0m[3]	17m	A
2				INTERIM 2 LANES	27.0m	17m	A
3			RIPARIAN PARKWAY	ULTIMATE 4 LANES	27.0m[3]	17m	A
4				INTERIM 2 LANES	27.0m	17m	A
5			TYPICAL	ULTIMATE 4 LANES	27.0m[6]	15m	B
6				INTERIM 2 LANES	27.0m	9m	C
7		MINOR	PARKWAY		27.0m	17m	A
8			TYPICAL		27.0m	9m	C
9			MAIN STREET		28.0m[4]	20m	D
10	COLLECTORS	MAJOR	RESIDENTIAL		22.0m	11.3m	E
12			LIVE/WORK		22.0m	12.0m	F
11		MINOR	BUSINESS PARK		22.0m	13.0m	G
13			RESIDENTIAL		22.0m[7]	11.3m	E
14	LOCALS	RESIDENTIAL	TWO-WAY		20.0m	10m	H
15			QUEUEING		17.0m	8m	H
16			ONE WAY		15.0m	6m	H
17		COMMERCIAL	BUSINESS PARK		20.0m	8.0m	I
18	LANES	RESIDENTIAL			6.0m	4m	J
19		COMMERCIAL			8.0m	5m	K

Notes:

(1) Paved width includes median width and continuous parking lanes/pockets but excludes intermittent parking pockets and left turn bays.

(2) "Cross Section Code" refers to the proposed street standard cross sections (See Figures 6.2.5 to 6.2.15).

(3) *The most desirable Parkway Ultimate standard would have a full 4.0m treed median for its entire length if 29m of right-of-way can be obtained during the development process, and the extra cost covered by Park DCCs. 27.0m only provides for a 2.0m median with low plantings between intersections, with localized widening to 4.0m in advance of intersections where left turn bays are required.*

(4) *The Mainstreet Arterial RoW is 1.0m wider that current City Arterial standards; however, this cross section provides for angle parking on both sides of the street, which results in higher on-street parking supply. It is expected that developments fronting Mainstreets would have reduced on-site parking requirements due to the provision of more on-street stalls, so this could act as an incentive to owners to provide the additional dedication width.*

(5) *Road Development Cost Charges (Road DCCs) are based upon street types No. 1-12 only. Minor Collectors, Local Roads and Lanes are not DCC eligible.*

(6) *196 Street will require 30m right-of-way throughout its length in East Clayton, 64 Avenue to 68 Avenue, due to topographical constraints.*

(7) *The 70 Avenue "Greenway" requires 1.5m additional right-of-way for a 2.5m sidewalk on one side, as well as 2.0m right-of-way for an additional row of street trees, for a total of 25.0m.*

Figure 6.2.3 illustrates the proposed road network plan for East Clayton. The "Cross Section Codes" refer to the various street cross section types, as described in the following section. Note that while the Arterial and Collector designations and alignments are relatively well defined, the Local street configurations shown on this figure are considered preferred/desirable concepts which shall be reviewed and refined as development proceeds. The Local street layouts on ***Figure 6.2.3*** reflect the sustainability principles embraced by the plan. The City during the development process may consider alternative layouts, which are proven to achieve the same transportation goals and drainage performance standards. In particular, the roadway Right of Way (ROW) and the network layout includes various drainage measures which are designed to promote in-ground disposal of stormwater through infiltration.

Figure 6.2.3 also indicates locations of existing and potential future traffic signals. The proposed traffic signal locations were based upon engineering judgement, not detailed traffic impact/signal warrant analyses. Generally, it can be expected that most Arterial/Major Collector and Arterial/Minor Collector intersections will require traffic signals by the full build-out of Clayton. Some of the Major Collector/Minor Collector intersections may also require traffic signals. Most other types of intersections could be effectively controlled through stop signs, either with 4-way stops or 2-way stops. Specific traffic control requirements will evolve over time as vehicular traffic grows due to new development.

Proposed Local road access to Arterials and Major Collectors is more frequent in the East Clayton NCP than that typically found in other neighbourhoods of Surrey with more conventional suburban development patterns. This feature of the plan is intended to support the "open" grid network concept by diffusing traffic among multiple routes. However, only selected local roads will have full movement access to Arterial roads; most will have right-in/out movements permitted only. While right-in/out traffic movements are not typically problematic on/off Arterial roads, permitting left turns can sometimes be difficult from a safety perspective. Therefore, the Local road access concepts presented on ***Figure 6.2.3*** are subject to detailed review during the development stage and/or the design stage for Arterial road upgrading.

6.2.3.3 Refinements to Recommended GNCP Major Road Network Plan

During the development of the East Clayton Road Network Plan, several refinements were made to the May, 1999 version of the GNCP Major Road Network Plan. These were:

- The proposed Major Collector on the 65/66 Avenue alignment between 192 Street and 196 Street was designated a Minor Residential Collector;
- 196 Street between 64 Avenue and 72 Avenue was designated a "2 Lane Arterial", with right-of-way protection for a future 4 lane facility (refer to Reference No. 7 in Appendix A.1). A functional design study of this section of 196 Street at 4 lanes was carried out by Reid Crowther & Partners under separate joint contract with the City of Surrey and Township of Langley. The required right-of-way for 196 Street was established at 30m; this width is greater than the City's existing standard of 27m due to the grades on 196 Street;
- 188 Street, a designated 2 lane Major Collector road, is expected to require 2 additional travel lanes between Fraser Highway and 68 Avenue due to the peak hour traffic volumes forecasted in this short section. In addition, a future traffic signal at 188 Street/68 Avenue will probably be required. These recommendations should be confirmed at the time of the development of the Business Park and Live/Work area.

Figure 6.2.4 illustrates the Refined Major Road Network Plan for the Clayton GNCP with the above noted changes.

6.2.3 Street Cross Sections

Alternative and more environmentally sustainable street designs are a critical component of the East Clayton NCP. Street designs were discussed at length during the Charette process, both with the entire Design Team, the East Clayton Citizens Advisory Committee (CAC) and during meetings with a sub-committee tasked with development of specific cross sections. At the outset, it was agreed that there were some fundamental principles for the design of the road cross sections in East Clayton, as follows:

- The performance standards for drainage will not be compromised by the new street designs;
- The street rights-of-way will be the same or less than current City standards, except where the additional width is needed for drainage and/or amenity requirements.

Appendix A2 contains figures that illustrate the proposed Arterial, Collector, Local Road and Lane cross sections for East Clayton. The letters in the upper-right hand corners of these figures represent the "Cross Section Codes" noted in ***Table 6.2.1*** and ***Figure 6.2.3***.

Other key design principles are noted below:

- East Clayton's street drainage systems must be capable of dealing with the five-year storm without flooding the travel portion of the street.

- "Open" drainage systems are to be used in as many street designs as possible, utilizing small and shallow swales/gravel infiltration pits, combined with a perforated pipe for water conveyance once the pit is saturated. Under trees, the perforations should be discontinued so that street trees do not experience saturated soil conditions.

- The maximum infiltration rate expected from the proposed shallow infiltration pit system is about 2.0mm/hr. In the winter, due to saturated conditions, this rate would be reduced to about 0.5-1.0mm/hr. It is expected, therefore, that the perforated pipe would act like a conveyance pipe several times during the winter months, conveying water to the deep injection wells and the storage/retention ponds. The infiltration function and the conveyance function of the perforated pipe system are required to avoid too frequent surface flow within the swales and to convey flows into the deep infiltration wells/stormwater ponds, respectively.

- The design flow for the swale system will not be appreciably affected by the 0.5 to 1.0mm/hr infiltration rate of the shallow infiltration systems during saturated winter conditions. Therefore, the surface of the swales will be required to convey water during most storm events. The swale system must be designed to address surface flow for the 5-year storm event with no road or boulevard flooding, and for the 100 year event with a maximum depth of 250mm permitted on the roadway surface.

- The surface flow system must be as continuous as possible; breaks caused by driveways must be minimized through the use of rear lanes (and use of shared driveways where rear lanes are not possible). When trees are located near the swale system, the area of saturated soil must not encroach to the root area; both underground and surface flows must be able to continue around the trees.

- For Arterials and Major Collectors, barrier curbs and gutters should be used due to the higher speeds and traffic volumes, to ensure pedestrian safety. However, the minor underground storm sewer systems required with the curb and gutter system would drain only the road surface, and the runoff must be directed to bio-filtration systems.

- Reduced water quality associated with use of the curb and gutter must be addressed through design (e.g., directing the runoff to other bio-filtration systems such as the proposed riparian stream).

- All new street cross sections for Arterials and Major Collectors should follow the City's current policy of integrating cyclists on the travel way, through the use of wider curb lanes or bicycle lanes. For Minor Collectors and Locals, vehicular volumes and speeds are intended to be such that separate bicycle facilities are not necessary. "Enhanced" integration routes on Minor Collectors or Locals can be considered when Greenways are located on-street rather than on a separate pathway, as proposed for the 70th Avenue Greenway.

- Business Park streets should be designed to address the higher number of larger trucks expected on this type of street. On-street parking should only be provided along the frontage of the Live/Work area.

- The design approach to Business Park streets requires property owners to address run-off quality. Bio-filtration mechanisms should be provided on-site in the Business Park (for example, through a pond/stream system), as illustrated in Cross Section G, ***Appendix A2.6***. The road drainage must be directed to a common facility, located on private property with a City right-of-way.

- There may be need to limit the number of trees on the side of Local streets, which contain the swale or where driveways are present. If tree spacing is not attractive (8-10m is desirable for small/medium trees for a continuous canopy) then other options are available:

    - Smaller trees;

    - Variable tree spacing;

    - Street trees on private properties close to front property lines.

- The infiltration requirements override the street tree requirement on the side of Local roads, which incorporates the drainage feature.

- 4m vertical clearance is required for Fire Trucks according to the BC Building Code. Street tree species for Local roads will have to be carefully selected and/or trimmed to ensure adequate vertical clearance, since several Local road cross section incorporate narrower travel ways.

- On Local roads with block lengths greater than 100m, a clear width of 6.0m is required for fire truck horizontal clearance, so parking may have to be prohibited one side of longer "queuing" streets, effectively turning them into two-way streets. On Local roads less than 100m in length, fire trucks would set up on the closest intersecting street and carry equipment to the fire incident. Fire hydrant locations should, therefore, be carefully planned.

- The encouragement of on-street parking is an important concept for East Clayton streets; it narrows the effective width of street pavements and contributes to the traffic calming effect. On-street parking should only be prohibited on "Ultimate Arterial" streets where 4 travel lanes are provided.

- Rear lanes are important for achieving the sustainability principles of East Clayton. They permit narrow lots, which are not dominated by front garages, garbage collection in the rear, additional on-street parking supply and a "finer" pedestrian/cyclist network. In addition, driveways will not interrupt the swale drainage system proposed for East Clayton.

- There may be some locations where rear lanes are not feasible due to topography or other reasons; in these cases, driveways must be used. In order to reduce the impact of driveways on the overall "sustainability" concept, they should be shared between adjacent properties and their widths kept to a minimum (3.5m) at the boulevard/sidewalk/roadway interface. Driveways could flare slightly on private property to provide on-site vehicle storage, in addition to garage storage. Driveway surface materials must be specified to support the sustainability principles for East Clayton (for example, porous pavement, gravel or gravel/grass). Driveway crossings of the infiltration pit/swale system must be carefully designed to ensure continuity of surface water flow during saturated conditions yet still allow safe access for residents.

- Garage rear setbacks (1.0m minimum) in lanes are required to accommodate turning movements.

- Parking in commercial lanes can be permitted between driveways and hydro poles in signed/marked locations.

Appendix A.2 contains a detailed chart of "Performance Measures" for each of the East Clayton street cross sections. ***Appendix A.3*** contains information about traffic calming measures which would be appropriate for various street types in East Clayton; note that many of these measures have been directly incorporated into the East Clayton street designs.

6.2.4 Alternative Modes

6.2.4.1 Commuter Bicycle and Pedestrian Networks

The entire bicycle network in Clayton will be comprised of both on-street and off-street routes. Typically, on-street routes are oriented towards "commuter" cyclists, while off-street routes are oriented towards "recreational" cyclists, although their purposes can overlap. The City's current policy is to integrate cyclists on all roads as well as providing separate, recreational routes on shared, multi-use pathways. Although there will be designated/signed main bicycle routes, the City's policy is that all roads in Surrey eventually will be "bicycle-friendly". The East Clayton plan and road cross sections has been developed using this philosophy.

Figure 6.2.5 illustrates the East Clayton NCP Commuter Bicycle Network Plan, with "Core", "Secondary" and "Greenway" routes. The GNCP Commuter Bicycle Network Plan was used as the basis for ***Figure 6.2.5***. Note that there are many other recreational and/or Greenway routes planned for East Clayton, as shown on the land use plan, but these are not considered major commuter routes and are not, therefore, part of the Commuter Bicycle Network Plan. The routes shown on ***Figure 6.2.5*** would be eligible for funding through Road Development Cost Charges, while other routes proposed in the East Clayton NCP would not be eligible.

The Arterial and Major Collector road cross sections for East Clayton include space for either wide curb lanes of 4.5m, or bicycle lanes/shoulders of 1.3-1.5m. Special facilities for cyclists on Minor Collectors or Local Roads are not required, since the traffic speeds and volumes of vehicle traffic are expected to be low. Greenways which coincide with commuter routes as shown on ***Figure 6.2.5*** should have multi-use pathways incorporated within them, at least 3.0m (and preferably 4.0m) wide, constructed of porous pavement.

The pedestrian network in East Clayton will be comprised of the 1.2m-1.5m wide sidewalks provided within each of the street rights-of-way, the off-street multi-use pathway system and Greenways, as well as other off-street pedestrian links which will be defined by the City as development proceeds. The road sections for East Clayton have all been planned with sidewalks on both sides of the street, buffered from the travel way by boulevards, street trees and/or parked cars to maximize pedestrian level of service. In addition, the rear lane system shall also serve as part of the pedestrian network. Many of the street cross sections indicate that curb pinching at intersections would be appropriate to minimize pedestrian crossing distances.

While planning pedestrian linkages between streets, care should be taken to ensure convenient pedestrian access to transit stops and shopping opportunities, as well as protected pedestrian crossings of major roads. School crossing safety is of particular importance and must be part of the detailed planning and design for new schools in East Clayton.

6.2.4.2 Potential Transit Routes and Facilities

The East Clayton road network will also be utilized by transit vehicles. BC Transit's current future plans in the area include Rapid Bus on Fraser Highway and 200 Street (with 10-minute headways during the peak demand periods) but with no specific services planned for Clayton itself. However, it is expected that with the urbanization of the Clayton area, additional internal transit services will be viable. The higher residential densities and employment opportunities in the business park embodied in the East Clayton land use plan, in particular, would support reasonably frequent transit service on its internal road network, likely with 15 to 30 minute headways in the peak periods. These services could be logical extensions of transit routes already provided for the City/Township of Langley. The proposed modified grid system is good for attractive transit service since it offers more direct and convenient pedestrian routings to bus stops and it offers more direct and flexible transit routings.

It is unknown at this time which streets within Clayton could become transit routes in the future; however, it is reasonable to assume that all Arterial roads and Major Collector Roads could be potential candidates, as well as selected Minor Collectors. The road cross sections have been developed with this assumption in mind.

While BC Transit has identified a future transit exchange/park and ride for the Willowbrook Mall area, there may be a need for a small transit exchange facility within Clayton to support the increased transit service to this area required to achieve the principles of "sustainability". It is recommended that consideration be given to planning for such a facility. Potential locations and physical requirements for this facility should be discussed with BC Transit; the proposed "village" at 188 Street/72 Avenue may be an appropriate location as it will be a key destination point within the Clayton area.

A small, local park and ride facility within East Clayton for residents only could be incorporated within the Business Park, with convenient pedestrian connections to the future Rapid Bus station on Fraser Highway. Bicycle lockers should be provided at this facility to encourage commuting by bicycle/transit.

SECTION 6.3

SANITARY SERVICING SYSTEM

6.3.1 Introduction

Section 6.3 describes the proposed sanitary servicing scheme to convey the sanitary flows generated within the East Clayton Neighbourhood. This plan presents a servicing scheme for the NCP in conformity with the City's long-term servicing strategy for the entire area. The report also identifies upgrading needs for the existing off-site systems, resulting from the projected flows from the East Clayton NCP area.

6.3.2 Design Criteria

The sanitary sewerage flows for the East Clayton NCP was estimated using the City's design criteria summarized herein-below on the basis of ultimate development scenario with population densities applied only to the designated developable areas; i.e. roadways, parks and other environmental reserves were excluded when computing the contributing population.

This design approach provides the recommended safety factor to meet the sanitary servicing needs of the future, as densities could change upwards; sewer upgrading work would be uneconomical for such incremental changes.

a) Design Population by Land Use Designation

Land Use	Maximum Units Per Acre	Assumed Number of People per Unit	Assumed Number of People Per Hectare
Work / Live	25	2.8	173.0
Live / Work	25	2.8	173.0
100’ Frontage Lots	7	3.2	55.3
6-10 u.p.a.	10	3.2	79.1
10-15 u.p.a.	15	3.2	118.6
15-25 u.p.a.	25	2.8	173.0
25-45 u.p.a.	45	2	222.4
Special Community	15	2	74.1
Commercial / Residential	15	2	74.1
Neighbourhood Commercial	15	2	74.1
Techno / Business Park	18	2	89.0
Institutional	10	2	49.4

Type of School	Population (people/school)	Approximate Area (ha)	Equivalent Land Use based Population Per Hectare
Elementary	500	4.3	45
Secondary	1200	8.0	45

b) Equivalent Population Component

Daily average per capita flow = 350 litres

c) Peak Flow Rate

Sewers will be designed to carry the total peak flow rates under free flow conditions. The peak flow rate is computed as a sum of peak dry weather flow resulting from wastewater and the Infiltration/ Inflow allowance. Peak dry weather flow is the mean rate during the maximum 15 minutes for any 12-month period. Peaking factors is the ratio of peak to average flows for the contributing population. These are calculated using Harman's Peaking Factor.

Harman's Peaking Factor: $1 + 14 / (4 + (\text{population}/1000)^{0.5})$ minimum value 2.5
maximum value 3.8

d) Sanitary Sewers Design

Sanitary sewers are to be designed using open channel hydraulics with invert slopes designed to satisfy the required flow conditions.

Capacity shall be provided to accommodate peak flows, corresponding to the potential population density at saturation and land-uses fully realised in accordance with the Official Community Plan.

To avoid full-bore flow from unaccountable surges, the depth of flow under maximum design condition, has been designed so as not exceed 50% of the internal diameter of the sewer.

Hydraulic analysis was carried out assuming steady state conditions and using Manning's Formula.

For full flow conditions: $Q=1/nAR^{0.66}S^{0.5}$; $n=0.013$.

The minimum sewer size has been designed as follows:

For residential lands - 200mm diameter
For industrial lands - 250mm diameter

All sanitary sewers are assumed to have been designed at grades to ensure sewage flow with a minimum self-cleansing velocity of 0.6 m/s, based on flow from development upstream. Upstream sections require steeper grades to ensure self-cleansing velocity under partial flow conditions, as a result, upstream sections will require a minimum grade of 1%.

A sewer shall be installed maintaining a depth sufficient to provide appropriate service connections to all properties tributary to the sewer. The optimal cover required, as per the latest updating of Standards is 2.5 m.

6.3.3 Offsite Service and Servicing Scheme Orientation

The total Clayton NCP area is shown in ***Figure 6.3.1.*** It is bounded on the South by the Fraser Highway, on the North and the West by the lowland and Agricultural Land Reserve (ALR) boundary and on the East by the 196 Street forming the Surrey/Langley border. The total area is approximately 852.3 ha. The City has planned to eventually service this entire area by directing the flow generated within this area to the GVS & DD interceptor sewer located to the south of this area, flowing westwards from 188 Street at 52 Avenue.

As shown in ***Figure 6.3.1,*** previous long-range planning work by the City, has identified the following off-site facilities to receive flows from the Clayton area:

	Off-Site Trunk Sewer	Serviced Area from Clayton NCP	Present Status and Updating Needs
1	Langley Bypass Trunk sewer from 64 Ave/196 Street, south-westerly to GVS&DD trunk sewer gravity section, at 52 Ave./ 188 St.	Southeast sector south of 72 Ave., approximately 188 ha.	• Identified in the City's 10-year Capital Plan; • Alignment and design to be completed prior to construction. • Requires design services/update to accommodate East Clayton area Servicing needs. Planned for design in 2000.
2	68 Ave. trunk sewer, conveying flow west to the trunk sewer mentioned in 4 below.	South central sector, approximately 101 ha.	• Constructed up to 188 St.
3	70 Avenue trunk sewer, Fraser Highway to 177 St., approximately.	Southwest sectors approximately 78 ha.	• Conceptual layout identified as part of the North Cloverdale West NCP; • Requires design review and updating based on proposed East Clayton NCP servicing needs.
4	Trunk Sewer from 72 Avenue / Fraser Highway, south to 60 Ave. along approximate alignment of 177 St. [As an interim measure, the City provided facilities mentioned in 5 below, to permit development to proceed, thereby generating DCCs to pay for the ultimate system.]	Northern sector north of 72 Ave., approximately 485 ha. [Also intercepts flows from 3 & 4 above.]	• Conceptually identified, conventional trench and cover North of 68 Ave. and micro-tunnel for the deeper section South of 68 Ave. • Part of it from Fraser Highway to 68 Avenue is funded for upsizing in the 10-year Capital Plan • Requires design/implementation review/updating based on total area servicing need forecasts.

	Off-Site Trunk Sewer	Serviced Area from Clayton NCP	Present Status and Updating Needs
5	Interim 68 A Ave. Pump Station @ 176 A St., and force main/gravity main to 60 Avenue approximately	On an interim basis, areas serviced into above trunk sewer along 68 Ave., 70 Ave. and 72 Ave./Fraser Highway to 68 Avenue. (amongst other areas from the west.)	• Interim Pump Station, force main, and gravity sewer constructed in 1996/97. • Interim Pump Station has limited capacity of 100 λ/s now, final design capacity is 400 λ/s. • Requires design/implementation review/updating based on total area servicing need forecasts.

The overall servicing scheme for the entire Clayton/Cloverdale area west of 176 Street has been delineated into 9 large sub-areas: A, B1, B2, C1, C2, D1, D2, E, and F as shown in ***Figure 6.3.1*** with sewer systems shown in ***Figure 6.3.2.*** It was developed taking into consideration the following key constraints and opportunities:

Opportunity / Constraint	How the Servicing Scheme Accounts For It
• The topography of the area	• Maximize gravity servicing function of the sewer system
• The watercourses/creeks traversing the area	• Minimize the number of watercourse crossings which interfere with continuous gravity flow grades of sewer lines
• Receiving capacity of the off-site trunk system	• Maximize conformance with planned / implemented plans
• Least distances to off-site trunk system	• Within the capacity limits, orient the on-site sewer system to minimize lengths, while meeting the other constraints / opportunities.

6.3.4 East Clayton NCP Area Sanitary Sewer System

The proposed sanitary sewer system relevant internally to East Clayton NCP area is shown on ***Figure 6.3.2***. The sewer system is designed with a minimum cover of 1.5m. This assumes that any below-grade basements in the area will require the sewage to be 'lifted' to the ground floor piping system connected to the street sewer. The optimum cover for these sewers would be 2.5 m.

Based on our analysis for the ultimate development flows, the recommended sanitary trunk sewers and a layout plan of the local collector sewers are shown on ***Figure 6.3.2***. ***Table 6.3.1*** summarizes the planned population and peak sanitary flow per catchment area. Using these peak sanitary flows, the performance of the existing sanitary trunks was evaluated. These results are summarized in ***Table 6.3.2***. Also using the peak sanitary flows per catchment area proposed sanitary trunks for the area were developed and is summarized in ***Table 6.3.2***.

Appendix B contains the detailed calculations used in developing the proposed sanitary sewer trunk system, as well as the calculations used to evaluate the existing sanitary sewer trunk system.

The following is a summary of the catchment areas and their servicing system arrangements.

6.3.4.1 Area Servicing into the Langley Bypass Trunk Sewer

Catchment A (168.3 ha) [Please note: No development can proceed within Catchment A without the completion of the first phase of the Langley By-pass sewer to relieve the current capacity constraints.]

This area drains southeast to the intersection of 64 Avenue and 196 Street. It will be serviced by three gravity sub-systems. The first sub-system will run south along 196 Street from 66 Avenue to 64 Avenue. This alignment is based on preliminary road alignments. The second sub-system will run east along 65 Avenue from 192 Street to 194 Street. The third sub-system will run south along 194 Street from 69 Ave to 64 Ave. The two sub-systems at 65 Avenue and 194 Street will then be combined into one sewer which will travel south along 194 Street to 64 Avenue, and then along 64 Avenue to 196 Street. Finally, the two sewers at 68 Avenue and 196 Street will be combined into one sewer along 196 Street from 64 Avenue and then connected to the proposed Langley Bypass Trunk Sewer. At the present time the proposed alignment along 196 Street indicates culvert will be used for the creek crossing at approximately 67 Ave. This alignment allows for the use of a gravity sewer, as the sanitary sewer will be placed above the culvert. However, if a bridge is constructed over the creek along 196 Street, a syphon that passes underneath the creek will have to be installed.

6.3.4.2 Areas Servicing into the ‘177 Street Trunk’ Sewer

Catchment B1 (114.9 ha)

This catchment is serviced by the recently constructed gravity sewer running south along 188 Street from 71 Avenue to 68 Avenue. The flows are then conveyed along 68 Avenue from 188 Street to the 68 Avenue Trunk at 184 Street. The 68 Avenue trunk will carry the flows initially, on an interim basis, to the Clayton sanitary pump station, and later to the ultimate “deep trunk” along the 177 St. alignment on a permanent basis.

6.3.5 Impacts on Existing System

6.3.5.1 Proposed Langley Bypass Trunk Sewer

The maximum contributing flows from the East Clayton has been re-estimated at 151.3λ/s. The existing sewer system south of Hwy. 10 and east of 192 Street is running at capacity and requires a relief trunk system flowing south-westward from Hwy. 10 to the GVRD trunk sewer on 52 Avenue at 188 Street. Hence, until such time as the relief trunk is complete and functional, development within this area will need to wait.

188 Street and 68 Avenue Trunk

The newly constructed 188 Street trunk sewer appears to be marginally undersized for the maximum population density. As a result, twinning along this undersized section may be required. However, if the maximum population density in not achieved the twinning of this sewer will not occur.

6.3.6 Conclusions & Recommendations

1. The sanitary servicing scheme proposed for the NCP area can adequately service the East Clayton NCP area, based on the proposed land use and saturation population densities. It is recommended that this servicing scheme be adopted for this area as a framework for planning, design and construction.

2. The layout and orientation, as detailed in ***Figure 6.3.1***, has been developed to minimize the number of stream crossings and optimize the system in respect of planned/available off-site connecting sewers. This servicing plan, when implemented will transfer the East Clayton sanitary flows (from Catchment Area A) to the existing westerly GVS&DD trunk sewer along 52Avenue, in accordance with the City's overall long-range servicing plan.

SECTION 6.4

WATER DISTRIBUTION

6.4.1 Introduction

This section outlines the water distribution system servicing requirements to meet projected demands and fire-flow requirements for the East Clayton NCP.

6.4.2 Existing System

The water supply system in the generalized Clayton NCP study area is separated into two pressure zones along approximately the 50 m contour. The upper or 'Clayton' pressure zone currently operates at 115 m static head and covers the East Clayton NCP Plan Area. The lower or 'Cloverdale' pressure zone operates at 90-m static head. (See ***Figure 6.4.1.***) Water supply to the overall area is provided by the new Clayton Jerico Main and the GVWD's Whalley/Clayton main which feed the Existing Clayton Reservoir at 72 Avenue and 190 Street.

The majority of the existing mains within the study are smaller diameter local mains (less than 300 mm diameter). There are existing grid mains of 300mm and larger diameter in the NCP Area on 188 Street south of 72 Avenue and on 72 Avenue from 184 Street to 196 Street.

The existing distribution system as of 1996 in the Clayton Generalized NCP Study area was evaluated as part of the City's Water Supply Study which assessed its' ability to meet the existing servicing needs.

Key findings included:

1. With the construction of the Clayton/Jericho main, the Clayton reservoir will be categorized as an unlimited source of supply at zero residual pressure (89m TWL).

2. Modification of the PRV set points to retain more water in the Clayton pressure zone has allowed the City of Surrey to defer the planned upgrading of the Clayton Pump Station. The HGL of the Clayton pressure zone will remain at 115m until the projected demand exceeds the existing pumping capacity of 321 l/s (3pumps @ 107 l/s).

3. Although the HGL of the Clayton pressure zone will ultimately be increased from 115m to 125m, in the East Clayton NCP area (south of 72 Avenue and east of 188 Street) the proposed feeder main loop has been upsized to allow servicing of this area at the lower HGL on an interim basis.

6.4.3 Proposed System

The total equivalent population that was calculated and used for evaluation of the water supply requirements of the Clayton Generalized NCP is 44,950.

For residential areas water demand was calculated on the basis of an average daily per capita allowance of 500 lpcd, a maximum day allowance of 1000 lpcd and a peak hour demand of 2000 lpcd in accordance with the City's design criteria. For all other areas such as commercial, institutional, etc. Table 2.3.1.4 of the City's Design Criteria Manual was used as a guideline.

A water network model of all of the pipes in the existing distribution system was prepared using EPANET. The input data for the existing distribution system was obtained from the input data of the City's CYBERNET water model. The proposed system was analyzed for both maximum day plus fire flow; and peak hourly flows.

Detailed analysis is summarized in the appendix. The analyses confirm that the proposed grid and feeder system will meet the City's design criteria for maximum day plus fire flow, and peak hour demands.

The following recommendations are made for the ultimate water distribution system for servicing of the land use concept for the East Clayton Generalized NCP Plan.

- Design the East Clayton system for an ultimate buildout equivalent population, based on the zoning of the preferred land use concept for the East Clayton NCP.
- Increase the HGL of the Clayton pressure zone from 115 m to 125 m when demands warrant and design the new Clayton pump station to provide a peak flow of 1,400 λ/s at 40 m TDH (including the immediate downstream discharge piping).
- Provide a grid and feeder main network for the ultimate development as shown on ***Figure 6.4.1***. Although the indicated pipe sizes represent the network required for the ultimate development scenario, it is possible that individual developers, that do not have the benefit of access to the ultimate looped distribution system, may have to upsize individual pipes to service their developments even on the basis of interim fire-protection.
- As development progresses and requires upgrading of existing inadequate system, have the existing 150-mm mains replaced with minimum 200-mm mains.
- No service connections should be allowed to the Feeder mains (450ϕ or greater).

SECTION 6.5

STORMWATER DRAINAGE SERVICING

6.5.1 Introduction

Context

As natural areas are transformed into urban development, the on-site and the off –site drainage servicing facilities are designed to meet environmental and public safety performance standards. The servicing needs to meet habitat preservation objectives and municipal by-laws to minimize drainage conflicts between lots as well as to provide protection of public safety and property from potential flooding and erosion.

Exploring and recommending ways and means of managing stormwater runoff in a more environmentally sustainable manner was one of the key objectives of the East Clayton NCP. The related concepts and how they are to be applied to the East Clayton stormwater drainage servicing scheme, are presented in this Section.

Local Rainfall and Runoff Characteristics

The yearly rainfall characteristics in Surrey are typical of those in the Pacific Northwest. The yearly recurring, 5-month wet weather period from October 31 to March 30 accounts for over 65% of the total average annual rainfall. During that period, evaporation rates are very low and the proportion of rainfall accounted for by infiltration losses to the soil are reduced due to saturation.

The 24 hour design, winter rainfall in the East Clayton area for different return periods (i.e., recurrence intervals) is summarized below. These values are based on the 35 year historical records at the Surrey Kwantlen Park rain gauge station from 1962 to 1996.

Return Period	**24-Hour Design Rainfall Data**	
	Depth of Rain in mm	**Peak hourly intensity (mm/hr)**
1-year or less	Up to 54.2	up to15.4
1 year to 5 year	54.2 to 82.9	15.4 to 23.4
5 year to 100 year	82.9 to 133.0	23.4 to 36.7

In any given watershed, rainfall is transformed into three main components:

1) **Evapotranspiration** through evaporation from exposed surfaces and transpiration by plants;

2) **Infiltration** into ground through pores in the surficial ground layers; and

3) **Runoff** over the surface.

The relative distribution among these three components is very different for rural and urban land uses. In the case of urban land use, the runoff component could potentially increase to 95% of the rainfall. To effectively handle this excessive runoff, a well-designed stormwater drainage system is needed.

In East Clayton, the planned building density, paved roadway areas, paved driveways and patios, as well as the application of traditional lot grading and landscaping practices will result in impervious surfaces and generate high surface runoff. Sustainable drainage management approach provides an opportunity to counter this high runoff trend. It requires the implementation of a drainage scheme that will encourage reversal of this high runoff process back to one that emulates the rural condition, as much as possible. Thus the sustainable development's approach will include means and measures to drain impervious areas through pervious areas/infiltration facilities (i.e. not allow direct connections to a storm sewer system); maximize natural ground covered green areas and tree clusters; and provide the use of stormwater infiltration measures on a lot by lot basis.

The local soil plays a key role in this innovative approach. The objective is to maintain and improve the permeability characteristics of the soil during and after development.

Local Soil Infiltration Characteristics

As discussed above, the key performance of managing storm water drainage in a sustainable manner is to minimize the runoff volumes generated from paved and landscape surfaces. Achieving such reductions in surface runoff in East Clayton is difficult due to the proposed development density and the clayey, silty, sub-soil prevalent in the area. In this context, a Hydrogeologic Assessment of the local sub-soil and water well data completed by Piteau Associates, Consulting Engineers, has shown that:

(a) On an area-wide basis, shallow (i.e. up to 2-meter depth) infiltration rates in the order of 0.5 to 1.0 mm/hour (i.e., 120 to 240 cubic meters/hour/day) could be achieved through these relatively impermeable clay-till layers in their natural state. This level of shallow infiltration represents a significant portion of the total seasonal rainfall, will potentially reduce runoff volume, and will add to baseflows in downstream watercourses.

(b) Under urban conditions, it is feasible to promote shallow infiltration by adopting various infiltration measures at all parts of the watersheds, and adopting different construction practices during fill material selection for landscaping of lots, etc.

(c) On an area-wide basis, there is a deep water bearing sand and gravel layer, underlying the Clayton upland area. This aquifer has the potential to act as a recharge area for stormwater runoff fed through recharge wells.

Figure 6.5.1 shows the potential recharge rates per well in different parts of the study area. These are broadly categorized into four zones of potential recharge rates as follows:

Recharge Zone	Recharge Rate per Well (l/s)	Approx. Area (ha)	General Location
Good Potential	50 l/s	77	North of 70 Ave from 188 St to 196 St.
Moderate Potential	30 l/s	56	South of 70 Ave, North of 68 Ave from 188 to 196 St.
Low Potential	20 l/s	72	South of 68 Ave, North of 67 Ave from 188 to 195 St.
Very Low Potential	10 l/s	66	South of 68 Ave to study area’s South boundary.

These preliminary rates are based on a review of available historical data and requires confirmation through field tests, as part of further follow up work prior to designing well injection facilities.

(d) These initial findings confirm that using appropriate designs, a significant part of the stormwater can be transferred into the regional aquifer under the study area. ***Figure 6.5.3*** is the schematic of a typical recharge (deep infiltration) well; it can be adapted to filter and transfer surface rainwater into the deep aquifer.

Off-Site Drainage Constraints

Drainage from East Clayton currently discharge to storm sewers and natural watercourses in Langley and Surrey. The post-development flow rates have to be controlled to levels which are similar to those under existing conditions. Summarized below are the approximate peak discharge rates from East Clayton into Langley. These rates and their site specific connection points are proposed to be the basis of an agreement between the two municipalities:

Location	**Peak Discharge Rate (m3/s)**	
	5-Year	**100-Year**
Outfall along 68 Ave, East of 196 St. to Langley	0.1	0.3

Location	**Peak Discharge Rate (m3/s)**	
Outfall South of 68 Ave, East of 196 St. to Langley	0.5	1.4
Outfall at 65 Ave, East of 196 St. to Langley	0.3	0.6
Outfall Along 64 Ave, East of 196 St. to Langley	0.1	0.2
Total	**1.0**	**2.5**

6.5.2 Drainage Servicing Scheme

Based on the above guiding needs, constraints and opportunities, a storm drainage servicing scheme concept was developed for the area. The overall servicing scheme is shown in ***Figure 6.5.2*** and briefly described below:

Service Area

The service area comprises of a number of drainage catchment areas as shown in ***Figure 6.5.2*** and summarized in ***Table 6.5.1***. There are no external drainage areas on the upstream, which will flow through East Clayton. Based on the proposed land use, the percentage of the total impervious area (TIA) varies from 46%, to 90%. The objective of the proposed servicing scheme is to achieve a much reduced effective impervious area (EIA), in terms of the surface flows to the downstream receiving systems.

Servicing Scheme Components

The overall servicing scheme comprises of four key components:

- **On-lot measures** for in-ground disposal;
- **On-street measures** for in-ground disposal and conveyance;
- **Recharge Wells** for in-ground disposal, and
- **Community Detention facilities** for detention, infiltration and controlled discharge to receiving waters.

Each of these facilities is to provide in-ground disposal of rainwater during all meteorological events spanning from everyday rainfall events to very rare events, which statistically occur once in 100 years. These components are further described below.

6.5.2.1 On-Lot Measures

On-lot drainage areas will cover about 70% of the watershed. The paved areas comprising of the planned buildings, driveways, and patio areas will generate significantly high levels of surface runoff. In addition, traditional landscaping of grassed/treed areas does not encourage percolation of rainwater into the ground. Furthermore, during wet winter season the percolation capacity of soil is reduced due to antecedent rainfall and the evapotranspiration losses through tree leaves are also reduced due to cold temperature and reduced leaf cover.

Therefore, the adoption of innovative designs to manage on-lot drainage through in-ground infiltration is a must for this development area. For example, by reducing the total impervious surface area and by routing the drainage from these impervious areas through pervious areas/infiltration facilities (i.e. preventing direct connection to the drainage system), net stormwater runoff can be reduced significantly. Similarly, by maximizing the use of pervious soils in the grassed areas, and the use of below ground enclosed infiltration trenches, runoff can be reduced. These dispersion Best Management Practice (BMP) facilities and the shallow infiltration facilities will handle the frequent rainfall events of a recurrence interval of once every month. To achieve this level of control, these measures have to be implemented in each lot, at depths below those affected by construction related compaction of the natural sub-surface soils.

To meet the above objective of significantly higher in-ground infiltration of rainwater, the traditional land grading, landscaping and lot drainage design practices have to be modified. It is therefore recommended that practices and measures similar to the following be adopted, as part of the land development application approval process.

Design Guidelines

a. The in-ground disposal facilities should be capable of infiltrating at a rate of 12 to 24 mm/day (or about 120 to 240 cubic meters per ha. per day) over the total area, as a minimum.

b. The drainage from all paved areas such as roofs, patios, driveways should be directed into various infiltration facilities within the property and not directly connected to the street storm sewer system.

c. In all new developments, native vegetation and soil must be maintained until building permit applications are approved. All areas except those earmarked for buildings must be protected from heavy machinery related compaction to protect the natural permeability characteristics.

d. The land clearing, regrading and landscaping guidelines have to be changed from current practice. Topsoil must not be removed from the project site, but placed on the lots.

e. The on-site infiltration best-management practices (BMP) measures such as the following should be implemented:

- Surface soil displaced by construction of services/houses must be replaced on site to maximize yard coverage with porous/permeable soils;
- Soakaway pits, grassed swales and rock filled trenches along property perimeter;
- Directing all building runoff through grassed/treed areas into the below ground infiltration facilities;
- Re-use through rain barrel and underground storage collection, and,
- Promote evapotranspiration losses by growing trees and bushes in each lot.

These measures are also briefly described in Section 5, Part 1 of this report under "Green Infrastructure".

6.5.2.2 On-Street Measures

The street/lane network typically covers about 30% of the gross development area. Traditionally, over 90% of the roadways are paved and contribute high runoff volumes and flow rates. In addition, the roadway network has to function as the overland flow conveyance system to safely convey flows up to the 100-year level storms. The traditional curb / gutter, catchbasin / sewer design provides for collecting and conveying the runoff from streets. This system is traditionally designed to carry the "5-year" level flows.

The sustainable development approach provides an opportunity to direct street runoff into grassed swales on either side. For small rainfall events, these swales can be used to treat runoff and infiltrate the runoff by making the soil base pervious / porous.

The roadway swales and perforated storm sewer system will supplement infiltration capacity of the preceding components. These two components play the vital role of safe conveyance of all runoff, including those from heavy and infrequent events such as the once in 100-year events. Thus they form the backbone of a good drainage servicing scheme. By this function, they are able to convey flows to the deep infiltration wells, the community detention ponds and the receiving watercourses.

The effective stormwater run-off rate from the East Clayton catchment area will be reduced due to the implementation of various infiltration measures within each lot and along roadway swales. Therefore, the trunk conveyance system, which will convey flows to the detention ponds, has been sized to convey the 2-year design event. Trunks, which convey flows from the detention ponds, have been sized to convey the peak pond 5-year release rate. A preliminary layout of the proposed trunk sewer system is shown in ***Figure 6.5.2*** and tabulated in ***Tables 6.5.2.*** and ***6.5.3.***

Appendix C also contains the Rational Method calculations used to size the storm trunk sewer system for the East Clayton catchment area for the both scenarios (with and without deep injection wells).

Design Guidelines

a. To effectively manage excess runoff resulting from all rainfall events (i.e., from 2 to 100-year recurrence frequency) a continuous overland flow path and a sub-surface storm sewer system are required as an integrated continuous conveyance system so as to minimize public inconvenience to an acceptable level. The preliminary layout shown in ***Figure 6.5.2*** and ***Table 6.5.2*** provides the overall guidelines.

b. The storm sewers must be placed within a continuous network of infiltration trenches to promote infiltration, and their design must ensure that they will be used to convey flow, only when the trench becomes saturated.

c. The integrated design of roadways and the on-street drainage facilities is a critical component of the follow-up design and construction process. The related key issues and needs are described in the Transportation Section of this report (under "street cross-sections"). These should be complied with on a site specific application basis.

d. As a minimum, the perforated sewer system must be designed to convey the full flows generated from the area for the 2-year level design storm, as per the City's current servicing standards. This downsizing of the design storm from the traditional 5-year level is a special provision for the East Clayton area that recognizes the value of the recommended plan to adopt in-ground disposal measures on an area-wide basis. The 2-year level flows are therefore, applicable only if all the on-lot and on street infiltration measures are fully adopted during the design and implementation of the site servicing of the developments in the area.

e. These perforated sewers must be used to promote infiltration by using soakaway pits and by perforating the sewers. This requires revising design standards on a NCP area specific basis.

6.5.2.3 Recharge (Deep Infiltration) Wells

As discussed in Section 6.5.1, the disposal of stormwater using distributed deep wells in the study area is included as a central component of the drainage servicing scheme. See ***Figure 6.5.3*** for a conceptual schematic of a typical well. As part of the preliminary servicing concept, these wells are included in those areas where the potential well flow capacity is estimated to be 30λ/s or over. The resulting flow distribution by each catchment area is tabulated in ***Tables 6.5.2*** *and* ***6.5.3***. This is a conservative approach as detailed information is currently not available. However, as recommended by the Hydrogeotechnical Consultants (Piteau Associates), additional field tests are required to maximize the potential recharge flow rate of each well and to increase the density of these wells over the total development area in East Clayton.

Design Guidelines

a. The recharge wells are to be designed as part as an integral part of the underground perforated sewer system for determining their locations, sizes and flow rate capacities and access requirements for future maintenance and operation. The case of large scale developments a similar concept must be used in conjunction with local, on-site servicing system. ***Tables 6.5.2*** and ***6.5.3*** demonstrates the design approach using the 2-year level storm which is equivalent to the traditional 5-year level design, as explained in Section 6.5.2.2.

b. The flow capacity targets for these wells are closely tied up with their location in the area and vary from 50 to 60 liters/second down to 10 liters/second. The expected reductions in peak flows resulting from various storms is their key performance measure. At this conceptual design stage, it has been set at a range of 30 to 60% of the peak runoff flow rates from each area during the 2-year storm, as shown in ***Table 6.5.2***. As these units are integral to the sizing of the storm sewer system and the community storage facilities, it is essential that, site specific field locations and their capacities be used at the next level of the servicing system design.

c. The discharge from these wells will replenish the regional groundwater aquifers. Therefore, the well design should incorporate filtration facilities as part of their design to improve the quality of the recharge water. As the watershed is a typical urban residential development and will stabilize over time, water quality is not expected to be a major impediment to their adoption as part of the servicing system components.

6.5.2.4 Community Detention Facilities

The sustainable development approach provides a practical opportunity to reduce the size/s of the detention ponds required to mitigate downstream impacts by implementing the in-ground disposal measures as discussed under lot drainage and street drainage. Appropriate storage volumes and locations to slow down the post-development flows to the above levels have been identified in the NCP and are discussed below. The detention ponds have to be designed and built in advance of developments.

The storage requirements of the stormwater storage facilities are dependent on the allowable peak flows to the downstream. The preliminary storage requirements and the peak pond outflow rates for each facility has been calculated based on the downstream constriction, the size of the contributing area and the flow reduction capacity of the upstream system's in-ground disposal measures. As part of the related computations, the inflow estimate to each stormwater storage facility has been calculated on the basis that there are deep infiltration wells in those areas classified as "Good and Moderate Potential". ***Figure 6.5.2.*** shows the approximate location of facilities and ***Table 6.5.4*** summarizes the approximate storage requirements for the 5-year, and 100-year design events for the option analyzed. ***Appendix C*** contains the stage/storage discharge curves for each of the ponds for the option that includes deep injection wells.

Table 6.5.4 summarizes the approximate pond construction, land, trunk construction, and deep well injection (if applicable) costs for both the option analyzed. As all stormwater storage facilities are 'wet' ponds, the land and construction costs associated with the dead storage have also been included. These costs are discussed in Section 7.0 of the report.

Design Guidelines

The City's current servicing standards should be followed for the location and design of these facilities. The storage values and the outflow rates should be based on site specific needs and constraints. The conceptual guidelines are, as discussed in this report, dependent on the planned drainage measures within each pond's contributing catchment. An initial estimate of these pond locations and their characteristics are presented in this report, as an overall guide to follow, during detailed designs.

6.5.3 Water Quality

The overall stormwater management plan recommended for East Clayton provides significant opportunities to protect the quality of stormwater generated in the area. Some of the related key measure which are part of the integrated Best Management Practices (BMP) approach include the following:

(a) Biofiltration measures: These are described in detail in ***Section 5*** of the report under "Green Infrastructure", and includes infiltration measures within each lot/building site; roadway swales, biofiltration facilities in developments and along roads, soil erosion control particularly during construction related surface regrading and stockpiling/moving of excavated/imported soils;

(b) Recharge (Deep Infiltration) Wells: All deep infiltration wells proposed for the area will be designed to include pretreatment of stormwater. These units will receive runoff from the watershed after being treated through the green infrastructure components such as the grassed swales, biofiltration ditches.

(c) Stormwater Detention Ponds: The stormwater ponds proposed for East Clayton are of the detention type. These facilities improve the quality of stormwater by promoting particle settlements. As well, those facilities can be designed to include additional biofiltration benefits by incorporating wetland components as part of their physical design. Furthermore, these detention facilities, at some locations in the watershed, could be used to supply improved water to the deep infiltration wells, thereby further enhancing water quality management in the area.

(d) Landscape Maintenance: There is an opportunity to promote environmentally friendly garden and landscape maintenance practices in the area, by developing appropriate guidelines for the benefit of and use by East Clayton residents. By encouraging such source control practices, contamination can be reduced.

6.5.4 Servicing Scheme Summary

The following is a summary overview of the proposed servicing scheme:

#	Component	Performance Role	Locations
1	Tree canopy • Trees/bushes in each lot boulevards, parks, etc.	Facilitate evapo-transpiration (E/T), add trees with high E/T potential in winter and summer.	All parts of the watershed.
2	On-Lot Measures • Eliminate direct connections from lots to street drainage system and • Adopt dispersion BMPs such as roof leader splash pads, vegetated flow paths, sheet flows on grassed/green areas, roadway swales.	To disperse stormwater runoff into pervious areas from paved areas and facilitate infiltration 0.5-1.0mm/day, or more where feasible.	All parts of the watershed with particular emphasis on paved area drainage redirection into vegetated and grassed areas.

#	Component	Performance Role	Locations
3	On-Street Measures Shallow infiltration BMPs such as Infiltration trenches, perforated pipes, buried in dispersion trenches, biofiltration swales, grassed swales along roads.	Facilitate collection of runoff generated from lots, roads, etc. and then promote infiltration as well as safe conveyance to detention facilities and receiving watercourses. • Minimum infiltration rates of 0.5 to 1.0 mm/hr. • Conveyance capacity to be at least 2-year level peak flow rates from the contributing watershed.	Along roadways, lanes and other drainage right of ways and making a continuous under ground/above ground system to convey storm runoff, eventually to the receiving watercourses.
5	Recharge Wells Deep infiltration wells are conceptually shown in ***Figure 6.5.3.***	To recharge the deep aquifers under Clayton area. The recharge rates will vary from 10 λ/s to 50 λ/s or more, as shown in ***Figure 6.5.1.***	Those areas marked as "Good, moderate and low potential" as shown in ***Figure 6.5.1.***
6	Stormwater Ponds Stormwater Detention facilities on a regional basis and within strata developments, commercial, and industrial sites.	To detain net runoff from upstream areas and then gradually release to the downstream receiving system. These facilities play a critical key role in managing flows into the existing downstream systems which may have capacity constraints. The minimum storage /area requirements for each contributing watershed are given in ***Table 6.5.4.***	Specific locations as shown in ***Figure 6.5.2***. Those locations are to be integrated with other community services such as parks, playing fields, etc., to facilitate cost reductions through joint use.

SECTION 6.6

IMPLEMENTATION

6.6.1 Implementation

The following recommendations are made to support the implementation of the East Clayton servicing plan:

6.6.1.1 Changes to GNCP Recommended Network

1. City staff should advise Council of the changes to the GNCP Road Network Plan and obtain Council's approval of the Revised GNCP Road Network Plan. The GNCP Plan should then be amended.

6.6.1.2 Further Studies and Analysis

2. The City should consider addressing the key issues and concerns expressed during the Charette process, either through further studies and analysis, or possibly through a "pilot project" in East Clayton, as follows:

6.6.1.2.1 Drainage

- Confirm required spacing and locations of trees to ensure swale drainage scheme can operate effectively. Determine if this spacing would be sufficient for aesthetics/urban forest policies.

- Develop detailed design/maintenance criteria for infiltration pits/swales, including depth, maximum/minimum grades, type of materials, sizes of pipes, swale dimensions and slopes.

- Develop design/cross section/spacing criteria for lawn drains in pits/swales connecting to perforated pipe.

- Confirm if drainage scheme in street cross sections needs to be larger or altogether different for varying densities and built forms

- Investigate drainage system configuration at driveway crossing and how to ensure continuous surface flow during major storm events while maintaining functionality of driveway. Establish design standards for driveway crossings of drainage system. Confirm if there would be significant loss of infiltration at driveway crossings, such that the drainage concept is compromised in areas with high numbers of driveways.

- Develop innovative and site specific best management measures to achieve bio-filtration within a storm sewer/detention pond system.

6.6.1.2.2 Street Trees

- Develop "performance measures" for the urban forest in East Clayton, such as percentage of canopy coverage for each street type.

- Develop a range of spacing of trees for longevity/cost/aesthetics for each street type, and listing of appropriate species for Clayton soil and drainage conditions.

- Confirm that in situations without rear lanes, where driveways, transformers, street trees and infiltration trenches are all competing for space in the boulevard, there would be sufficient area remaining for street trees. If not, re-consider allowing driveways or develop alternative cross section standards for development with driveways.

6.6.1.2.3 Utilities

- Obtain formal approval of street cross sections from all private utility companies.

- Develop alternative street lighting features, such as special decorative poles and pedestrian-scale lighting standards.

- Consider reduced street lighting levels on Minor Collector and Local roads to reduce energy consumption, with a full review of liability.

6.6.1.2.4 Parking

- Investigate alternative options to prevent drivers from parking on infiltration trenches/boulevards in Collector and Local roads; establish appropriate spacing and design criteria for such measures. Investigate liability issues of alternative options.

6.6.1.2.5 Alternative Surface Materials

- Investigate options for alternative pavements for roads and multi-use pathways (e.g., grass block, permeable pavements, gravel, etc.). Review both capital and maintenance costs.

- Determine if alternative/permeable pavements are necessary in any of the street cross sections for the proposed drainage concept to work effectively. Confirm if traditional asphalt would be acceptable.

6.6.1.2.6. Driveways

- Determine the conditions under which use of driveways should be considered appropriate.

- Develop new design standards/guidelines for shared driveways to complement the "sustainability" concept and reduce impact of additional hard surface (width, vertical grade, flaring on site, tandem parking, porous pavement/gravel, etc.).

- Investigate need for modifying Local and Collector road cross sections to account for driveways.

6.6.1.2.7 Intersection Design and Plan Elements

- Develop a series of generic functional intersection layouts, with all potential configurations represented, in order to establish intersection design guidelines, including design vehicles.

- Develop alternative design guidelines for accommodation of truck turning movements. For example, sweeping into opposing lanes/mounting curbs/sidewalks could be acceptable for large vehicles at Local and Minor Collector intersections to minimize turning radii/walking distances.

- Consult with the City's waste collection contractor, especially in regard to turning sight distance in rear lanes.

- "Prove out" the proposed street cross sections by designing a neighbourhood with the new cross sections, which includes centre-line profiles, plan views and intersection layouts of various street types, with street trees, utilities, on-street parking, lanes and driveways, and **drainage schemes all incorporated**.

6.6.1.2.8 Bike Network

- Confirm the proposed on-street bicycle route system with the City of Langley City and Township of Langley.

- Review vertical grades for the proposed bicycle network routes and confirm proposed routes are acceptable.

- Identify what street cross section changes, if any, are required to incorporate the proposed on-street Greenways. Establish design guidelines for On-street Greenways.

6.6.1.3 Development Process

3. Give consideration to the development of a unique Subdivision and Control Bylaw for East Clayton (and possible the whole Clayton area, if sustainability principles are also applied beyond the boundaries of East Clayton), which address street standards and design guidelines, drainage performance measures, implementation issues, etc.

4. Prepare both developers and City staff involved in land development and transportation to support the East Clayton NCP, by training them in the application of this new bylaw, as well as the overall development concept for East Clayton and sustainability principles in general.