

SOAH DOCKET NO. 582-15-2082  
TCEQ DOCKET NO. 2015-0069-MSW

APPLICATION OF § BEFORE THE STATE OFFICE  
130 ENVIRONMENTAL PARK, LLC §  
FOR PROPOSED § OF  
PERMIT NO. 2383 §  
§ ADMINISTRATIVE HEARINGS

**APPLICANT'S REPLY BRIEF**

TO: THE HONORABLE KERRIE JO QUALTROUGH, ADMINISTRATIVE LAW JUDGE  
AND THE HONORABLE CASEY A. BELL, ADMINISTRATIVE LAW JUDGE:

130 ENVIRONMENTAL PARK, LLC (130 Environmental Park), the Applicant in this proceeding, files this, its Reply Brief, addressing the matters identified in Orders No. 31 and 32:

1. TJFA/EPICC's assertion that the drainage analysis in the application was inadequate because it relied on mitigation of impacts beyond the permit boundary.
2. TJFA/EPICC's assertion that the drainage analysis in the application was inadequate because it did not disclose the specific unit hydrograph used in the analysis.
3. The newly-admitted affidavits of Patton King and David Green related to TCEQ's evidence of competency rule provision.

**1. The Drainage Analysis for the 130 Environmental Park Facility Does Not Rely on Mitigation of Impacts Beyond the Permit Boundary**

In their Response to Closing Arguments, TJFA/EPICC assert that the existing/postdeveloped drainage analysis in the Application is insufficient because of changes in runoff volume that will occur at comparison points CP7 and CP8. TJFA/EPICC claim that no analysis of these changes was made at the proposed permit boundary and that such analysis must be done "independent of an analysis of impacts to the reservoir". These assertions by TJFA/EPICC are incorrect and contrary to the evidence in the record.

TCEQ's rules require that a landfill permit application include a drainage analysis showing that existing drainage patterns will not be adversely altered as a result of development of the landfill. The analysis must be based on the 25-year, 24-hour storm, and consists of comparing peak flow rates, velocities, and volumes under existing conditions and postdeveloped conditions (after development of the solid waste facility) at various locations. *30 TAC §§330.63(c)(1)(C) and (D), 330.303, and 330.305(a); Testimony of Tyson Traw, P.E. Tr. pp.2010/l.13-17 and 2011/l.3-23; Testimony of Steven Odil, P.E. at Ex. ED-SO-1 p.23/l.14-p.24/l.4 and Tr. p.1906/l.3-7; Testimony of Tracy Bratton, P.E. at Tr. p.1859/l.17-p.1860/l.8.* This analysis is included in the Application, and includes evaluation of existing and postdeveloped conditions at various locations (comparison points) along the boundary of the proposed 520 acre permit boundary. In addition, in an example

of the Application exceeding requirements in TCEQ's rules, it also includes existing and postdeveloped analysis at comparison points located along the downstream property boundary of the 1,229-acre tract within which the 130 Environmental Park facility will be located. The Application includes an existing and postdeveloped analysis based on the 25-year, 24-hour storm, as required by the rules and, in another example of the Application going beyond the TCEQ rule requirements, it also includes existing and postdeveloped analysis based on the 100-year, 24-hour storm. *Ex. 130EP-2 pp.49, 59-62, 68-71, and 73-79.* The locations of the comparison points used in the analyses (which remained the same for the existing and postdeveloped conditions) are shown on the maps on the existing and postdeveloped runoff summaries. *Ex. 130EP-2 pp.76 and 78.* Tables comparing the runoff peak discharge, velocity, and volumes at each comparison point in the existing and postdeveloped conditions for both the 25-year and 100-year storms are in the Application at *Ex. 130EP-2 p.79.* The analyses in the Application show that there will be no adverse alteration of natural drainage patterns at either the permit boundary or the property boundary, in either a 25-year or 100-year rainfall event.

The comparison points about which TJFA/EPICC complain (CP7 and CP8) are located along the southeastern permit boundary for the proposed 130 Environmental Park facility. Those locations are within both the 25-year floodplain and the 100-year floodplain (as shown on the Postdeveloped Floodplain Workmap at *Ex. 130EP-2 p.260*), meaning that a 25-year storm event (and certainly a 100-year storm event) will result in the water surface of the Site 21 reservoir expanding onto the permit boundary, such that CP7 and CP8 are both located within the reservoir. *Ex. 130EP-2 p.69.*<sup>1</sup> Because TCEQ rules require the analysis of existing and postdeveloped conditions to be conducted based on the 25-year storm, in the conditions required to be evaluated water at CP7 and CP8 will be within the reservoir and it is not appropriate (or even possible) to evaluate changes at these comparison points "independent of an analysis of impacts to the reservoir": changes at CP7 and CP8 will be changes (impacts) to the reservoir. As the evidence shows, the impact to the reservoir will be a volume increase that represents less than 1% of the capacity of the reservoir during the 25-year storm event which is an insignificant increase. *Ex. ED-SO-1 p.26/l.14-17.*

The analysis of existing and postdeveloped conditions done to satisfy TCEQ's rules must, of course, be based on facts. In this case, those facts include the presence of the Site 21 reservoir and the floodplain associated with Dry Creek and its tributaries, facts that were used in the analysis in the Application. TCEQ's rules certainly do not require that existing/postdeveloped drainage analyses be conducted for every hypothetical situation that any party could imagine. However, even if the Site 21 reservoir did not exist and there were no 25-year or 100-year floodplains associated with Dry Creek, the changes at CP7 and CP8 would not be "adverse alterations". There will be an increase in volume at CP7, from 38.5 acre-feet to 61.8 acre-feet. However, because the peak discharge rate will be reduced and the increased runoff volume will be distributed over a longer time period, that increase would not result in an adverse alteration. *Ex. 130EP-2 p.69; Testimony of Steve Odil, P.E. at Tr. p. 1904/l.22-p.1905/l.7 and p.1905/13-16.*<sup>2</sup> There will be a

---

<sup>1</sup> The other comparison points located on the downstream sides of the proposed permit boundary, CP5 and CP6, are also located within the 25-year floodplain, and will also be within the reservoir in a 25-year storm. (*Ex. 130EP-2 pp.76, 78, and 260*)

<sup>2</sup> This conclusion and the cited testimony of Steve Odil, P.E. are consistent with the testimony of protestant's witness Tracy Bratton, P.E., that an analysis of "adverse alteration" should be based on

decrease in volume at CP8, from 63.8 acre-feet to 53.3 acre-feet (although the 53.3 acre-feet running off at CP8 in the postdeveloped condition will still be a significant volume of water). *Ex. 130EP-2 pp.69 and 79*. However, no water supply function occurs at that location, so no adverse alteration would result from the decrease. *Testimony of Johnnie Halliburton at Tr. p.1278/l.4-17 and Ex. Haliburton-1 p.37/l.7-21; Testimony of Steve Odil, P.E. at Tr. p.1904/l.22-p.1905/l.7*. Even considering impacts downstream from CP8, the decrease in volume could not result in an adverse alteration. Without considering the reservoir or floodplains, CP7 and CP8 are both located on drainage tributaries to Dry Creek. The tributary on which CP8 is located joins Dry Creek approximately 1,100 feet downstream of CP8, and the tributary on which CP7 is located joins Dry Creek approximately 350 feet farther downstream. Because of the increased water volume at CP7 (which increase exceeds the decreased volume at CP8), the decrease in water volume from CP8 could, at most, exist only in that combined 1,450-foot portion of the CP8 tributary and Dry Creek. After that, the volume increase at CP7 would more than make up for the decrease from CP8. Because there is no water supply that occurs along that 1,450-foot stretch, a decrease in water volume there would not be an adverse alteration. *Testimony of Johnnie Halliburton at Tr. p.1278/l.4-17 and Ex. Haliburton-1 p.37/l.7-21; Testimony of Steve Odil, P.E. at Tr. p.1904/l.22-p.1905/l.7*.

Finally, the areas at, above, and below comparison points CP7 and CP8 are subject to an existing drainage easement. *PCCD Ex. 1.1, pp.2-5*. The inundation area covered by that easement is shown in the Application (on the Facility Site Plan at *Ex. 130EP-1, p.131*). It includes the locations of CP7 and CP8, as well as areas upstream from them on their respective drainage tributaries and areas downstream from them, extending to and beyond the channel of Dry Creek.

## **2. The Specific Unit Hydrograph Used in the Drainage Analysis is Identified in the Permit Application**

In their Response to Closing Arguments (at page 50), TJFA/EPICC claim that the unit hydrograph used in drainage analyses in the Application has not been identified: “130EP continues to rely upon the use of the unit hydrograph method to determine drainage patterns, without identifying the particular unit hydrograph utilized.” This assertion is simply not true. The analyses in the Application uses the SCS Unit Hydrograph, as identified in several places.

As explained by Mr. Tyson Traw, P.E., 130 Environmental Park, LLC’s expert witness for surface water drainage and floodplains, during his testimony, the Application specifically addresses the unit hydrograph used in the analyses:

Q Does the TCEQ municipal solid waste permit application identify and describe the unit hydrograph that you used in the drainage analysis and design work you did?

A Yes.

---

consideration of peak discharge rate and velocity, but not volume, because “you can’t engage in any kind of development without increasing the total volume. (*Testimony of Tracy Bratton, P.E. at Tr. p.1859/l.17-p.1860/l.5*)

Q Do you have up there Exhibit 130EP-2?

A I do.

Q Can you identify for us where in the application it identifies and describes that unit hydrograph that you used?

A Yes, I can. It's been talked in a couple of places. The example -- the first one I turned to is Page 85, and it's under the heading topic "Synthetic Unit Hydrographs and Flow Routing." And it's in the first paragraph there under that heading.

Q Okay. And that includes a reference to TR55?

A It does.

Q And does TR55 include additional information about that SCS method in the unit hydrograph?

A It does.

Q Okay. Anywhere else in the application that refers to the specific unit hydrograph that was used?

A So we refer to that again on Page 121. In fact, that's the identical wording. It's just saying that we used the same method for the post-development analysis that we used for the existing.

Q Okay. Did you use any peaking factors in connection with your use of the unit hydrograph?

A No.

Q Why not?

A That unit hydrograph is developed by the SCS, and you don't apply peaking factors to that.

...

Q And you had some discussions with Mr. Ryan about unit hydrographs. Do you recall that?

A I do.

Q And I think you looked at Page 85 in Exhibit ED-2. We may not need to turn there. Let me go ahead and ask you a question. And does that indicate that you used the methods set forth in TR-55?

A Well, Tracy Bratton pointed this out the other day. But the method in TR-55 identifies the hydrograph, and it was established in 1986 before our ability to do all this with computers. So we actually used the HEC-HMS model that uses the hydrograph that's described in TR-55. But you don't go through the same tabular method described in TR-55.

Q Does TR-55 have only one unit hydrograph?

A Yes, sir, it does.

Q So only one set of data for one particular storm is set forth in all of TR-55?

A No. That would be incorrect.

Q Is it not true that there's data -- well, what types of things do you need to know in order to choose which unit hydrograph to use?

A Well, if you use the SCS method and the SCS unit hydrograph, once you determine that that's what you're going to use, that's it. There are no other peaking factors or any other assumptions necessary.

*(Testimony of Tyson Traw, P.E., Tr. p.2021/l.6-p.2022/l.12 and p.2126/l.6-p.2127/l.7)*

Use of the SCS method and the SCS unit hydrograph are also confirmed in the modeling information included in the Application on the disc (December 08, 2015, 130 Environmental Park, Part 3, Attachment C: Appendix C1 (HEC-HMS), Appendix C2) located just before Attachment C1 (*at Ex. 130EP-2 p.50*).

It is puzzling how neither TJFA/EPICC nor its expert witness, Mr. Robert D. Harden, could not know that the SCS unit hydrograph was used in the modeling in the Application, unless they had not reviewed the permit application and the modeling information on the disc included in the Application. Caldwell County's expert witness, Mr. Tracy Bratton, P.E., certainly knew prior to the time he submitted his prefiled testimony:

Q: Did the Applicant in this case present modeling of pre-development conditions and post-development conditions?

A: Yes. In Part III of the application, Attachment C1 Appendix C-2, the Applicant presented hydrologic calculations for the 25-year Water Surface Elevation, and the 100-year Water Surface Elevation.

Q: Was the HEC-HMS Model used in this evaluation?

A: Yes. The HEC-HMS Model was used to simulate the surface water runoff response of the watershed. In determining the surface elevations under specific circumstances, the HEC-RAS model was also used in conjunction with the HEC-HMS Model.

Q: Are you familiar with these models?

A: Yes.

Q: Can you please generally explain how the HEC-HMS and HEC-RAS models work?

A: HEC-HMS is a hydrologic model. It applies a time series record of rainfall specified by the user to a physical surface (a watershed) defined using several physical parameter (watershed size, time of concentration, impervious cover percentage, infiltration rate of the soil) to calculate a time series record of runoff flow rate measured in cubic feet per second (a hydrograph) at a location of interest. In transforming rainfall to runoff, the SCS unit hydrograph serves to provide a temporal distribution of runoff flow rate at the point of interest for each element of the rainfall hyetograph.

*(Testimony of Tracy Bratton, P.E., Ex. Caldwell 1 p.6/l.2-20)*

There is a lot of readily available information regarding the SCS method and the SCS unit hydrograph, including a publication of the National Weather Service, National Operational Hydrologic Remote Sensing Center (NWS/NOHRSC), Soil Conservation Service - Dimensionless Unit Hydrograph, available online at [ftp://192.46.108.3/staff/nilsson/web/uhg/scs\\_uhg.htm](ftp://192.46.108.3/staff/nilsson/web/uhg/scs_uhg.htm). The introductory paragraph of that publication, a copy of which is attached hereto as Attachment 1, states, in part:

The Soil Conservation Service (SCS) dimensionless unit hydrograph procedure is one of the most well known methods for deriving synthetic unit hydrographs in use today. References for this method can be found in most hydrology textbooks or handbooks. The primary reference for this method may be considered as the Soil Conservation Service *National Engineering Handbook, Section 4, Hydrology* (SCS

1972). There are a number of versions of this reference occurring both before and after the given date. The dimensionless unit hydrograph used by the SCS was developed by Victor Mockus and was derived based on a large number of unit hydrographs from basins which varied in characteristics such as size and geographic location. The unit hydrographs were averaged and the final product was made dimensionless...The dimensionless unit hydrograph is illustrated in Figure 1...

Finally, it is interesting that the SCS unit hydrograph shown in Figure 1 of the National Weather Service publication is identical to the unit hydrograph included by TJFA/EPICC's witness Robert D. Harden as an exhibit to his prefiled testimony in this case (*Ex. Protestant's 9-B*).

### **3. 130 Environmental Park, LLC Provided Appropriate Information Regarding Evidence of Competency**

In their Response to Closing Arguments, TJFA/EPICC make various arguments related to TCEQ's rule at 30 TAC §330.59(f) ("Evidence of Competency"). The positions set out by TJFA/EPICC are all without merit.

The primary focus of TJFA/EPICC's arguments in this regard is recent personnel changes for principals and supervisors of 130 Environmental Park, LLC and TJFA/EPICC's suggestions that, because of these personnel changes, the requirements of 30 TAC §330.59(f) have not been satisfied. Each of the assertions made by TJFA/EPICC is set out below, followed by 130 Environmental Park, LLC's response.

**A. TJFA/EPICC assertion:** "The Application...identifies Oscar Allen and Thad Owings, but does not specify their positions or roles with respect to 130 Environmental Park."

**Response:** As required by TCEQ's rule at 30 TAC §330.59(f)(4), Section 6.1 of Part I of the Application includes Mr. Allen and Mr. Owings in a list of "the names of the 130 Environmental Park, LLC principals and supervisors" (*Ex. 130EP-1 pp.50-51*). Because a "principal" is "the most important or senior person in an organization or group"<sup>3</sup> and the Application identifies Ernest Kaufmann as "President and Manager of 130 Environmental Park, LLC"<sup>4</sup>, it is clear that Mr. Allen and Mr. Owings are included because they are supervisors of 130 Environmental Park, LLC's organization.

**B. TJFA/EPICC assertion:** "...Allen and Owings were neither officers nor employees of 130 Environmental Park."

---

<sup>3</sup> *Oxford Dictionaries*, s.v. "principal", accessed December 15, 2016, <http://www.oxforddictionaries.com/definition/english/principal>.

<sup>4</sup> Mr. Kaufmann is identified as President and Manager of 130 Environmental Park, LLC at various places in the Application, including: the Part I form signature page (*Ex. 130EP-1 p.33*); "Management and Personnel" at Section 6.1, Part I (*Ex. 130EP-1 p.50*); and the Notice of Appointment (*Ex. 130EP-1 p.78*).

**Response:** TCEQ's rule at 30 TAC §330.59(f)(4) requires information about "the principals and supervisors of the owner's or operator's organization". That information, including information about Mr. Allen and Mr. Owings as supervisors, is in Section 6.1 of Part I of the Application (*Ex. 130EP-1 pp.50-51*). There is no requirement that supervisors identified pursuant to 30 TAC §330.59(f)(4) be "officers" or "employees".

**C. TJFA/EPICC assertion:** "There is no information in the application regarding these individuals' (or Green Group Holdings') affiliations with other organizations engaged in solid waste activities."

**Response:** TCEQ's rule at 30 TAC §330.59(f)(4) requires "the names of the principals and supervisors of the owner's or operator's organization...together with previous affiliations with other organizations engaged in solid waste activities." Section 6.1 of Part I of the Application includes that information for Mr. Kaufmann (including his having been an executive and manager with Browning-Ferris Industries (BFI)); for Mr. Allen (including his having been an engineer and executive for over 15 years, permitting and operating numerous waste to energy facilities around the United States with Covanta); and for Mr. Owings (including his more than 20 years in the waste industry working for BFI, Allied Waste Industries and Republic Services, with direct experience in all phases of landfill permitting, construction and management). Green Group Holdings, LLC is neither a principal nor a supervisor for 130 Environmental Park, LLC, so 30 TAC §330.59(f)(4) does not require any information about it.

**D. TJFA/EPICC assertion:** "Ernest Kaufmann is no longer the President or Manager of 130 Environmental Park or of Green Group Holdings...the representations included in the pending application regarding the Applicant's principals and supervisors are no longer accurate."

**Response:** Other than the requirement that a licensed solid waste facility supervisor must be employed "before commencing facility operation" (which is provided for in the Application), 30 TAC §330.59(f) is an informational requirement: it identifies information to be included in a permit application. The information regarding 130 Environmental Park principals and supervisors provided in the Application was current and accurate when the Application was submitted to the TCEQ in September 2013 and through the time the Application was declared technically complete in October 2014. Neither 30 TAC §330.59(f) nor any other TCEQ rule requires that this information, or other information provided in a permit application, be updated throughout the pendency of a contested case process. Imposing such a requirement would mean that an application could never be "done". Applicants would be required to constantly and repeatedly update their applications during contested case proceedings (which can last for years) regarding not only changes in personnel, but changes to things like area and regional land use and growth trends, adjacent property ownership, the names of elected officials and government representatives, etc.

In the context of the informational requirements in 30 TAC §330.59(f), recent personnel changes for principals and supervisors of 130 Environmental Park, LLC are not significant changes. These persons are identified in Part I, Section 6.1 of the Application (*Ex. 130EP-1 pp.50-51*) as 130 Environmental Park LLC's principals and supervisors: Ernest Kaufmann (President and Manager), Oscar Allen, Thad Owings, and a licensed and experienced Landfill Manager (to be employed before commencing facility operation, per 30 TAC §330.59(f)(3)). Following recent personnel

changes described in David Green's affidavit (*Ex. 130EP-61*), 130 Environmental Park, LLC's principals and supervisors are/will be: David Green (President and Manager)<sup>5</sup>, Thad Owings, and a licensed and experienced Landfill Manager (to be employed before commencing facility operation, per 30 TAC §330.59(f)(3)). The result of these changes is that David Green has replaced Ernest Kaufmann (both of whom have significant management experience with organizations engaged in solid waste activities), Oscar Allen (whose background is in the waste to energy business) will not be a supervisor of solid waste management activities at the 130 Environmental Park facility, and Thad Owings (who is now the Green Group Holdings, LLC Senior Project Manager for Landfill Operations and who holds a current TCEQ Class A municipal solid waste license) and a licensed and experienced Landfill Manager (to be employed before facility operation commences, as required by TCEQ rule at 30 TAC §330.59(f)(3)) will also be supervisors of the solid waste management activities at the 130 Environmental Park facility.

**E. TJFA/EPICC assertion:** “[T]here is no evidence that demonstrates Owings has actually had any involvement with 130 Environmental Park or that he has any experience related to the operation of a landfill.”

**Response:** As set out in Section 6.1 of Part I of the Application, Thad Owings has over 20 years in the waste industry working for BFI, Allied Waste Industries and Republic Services, with direct experience in all phases of landfill permitting, construction and management. Mr. Owings, who is now the Green Group Holdings, LLC Senior Project Manager for Landfill Operations and who holds a current TCEQ Class A municipal solid waste license, will be one of the supervisors of the solid waste management activities at the 130 Environmental Park facility (*Ex. 130EP-1 pp.50-51; Ex. 130EP-61*). Information regarding Mr. Owings satisfies the requirements of 30 TAC §330.59(f)(4) and (5).

**F. TJFA/EPICC assertion:** “The departure of Kaufmann also calls into question whether Applicant has complied with the requirements of Rule 305.44, which requires that the application be signed by a responsible corporate officer. Kaufmann signed the application, but he is no longer a responsible corporate officer, as defined by the rules.”

**Response:** This assertion, in itself, shows that it lacks merit. TJFA/EPICC are correct that 30 TAC §305.44 requires that an application be signed by a responsible corporate officer, and they acknowledge that 130 Environmental Park, LLC's permit application was signed by Ernest Kaufmann, who they do not dispute was authorized to do so. The Application signature page (*Ex. 130EP-1 p.33*) is part of a TCEQ form and includes the following: “I certify under penalty of law

---

<sup>5</sup> Effective July 26, 2016, David Green replaced Ernest Kaufmann as the principal (President and Manager) of 130 Environmental Park, LLC and as the President of Green Group Holdings, LLC (the sole member and 100% owner of 130 Environmental Park, LLC) as part of a planned transition, the timing of which was affected by recurring health problems that have limited Mr. Kaufmann's ability to travel. Mr. Kaufmann will retire as an employee of Green Group Holdings, LLC as of December 31, 2016, but will continue in a consulting capacity. Mr. Green's pertinent experience and previous affiliations with other organizations engaged in solid waste activities are described in his affidavit and in a portion of the transcript from his September 10, 2015 deposition in this matter (*Ex. 130EP-61 at pp.2 and 10-17; Protestants' Ex. 10 p.12/l.11-17*).

that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted” (emphasis added). Because the Application was prepared under Mr. Kaufmann’s direction or supervision while he was the President and Manager of 130 Environmental Park, LLC, he is the appropriate person to have signed the Application. That is not affected by the subsequent change of 130 Environmental Park, LLC’s President and Manager from Mr. Kaufmann to David Green.

**G. TJFA/EPICC assertion:** “The 130 Environmental Park landfill is...a proposed facility of Green Group Holdings. The other landfills owned by Green Group Holdings were not identified as required by TCEQ Rule 330.59(f).”

**Response:** Regarding other solid waste sites (including landfills), 30 TAC §330.59(f) requires that “(1) The owner or operator shall submit a list of all Texas solid waste sites that the owner or operator has owned or operated within the last ten years”, and “(2) The owner or operator shall submit a list of all solid waste sites in all states, territories, or countries in which the owner or operator has a direct financial interest.” The Application (at page 1 of the Part I form, *Ex. 130EP-1 p.17*) identifies the operator as “130 Environmental Park, LLC”. The Application also states, “130 Environmental Park, LLC, a Georgia limited liability company, is authorized to do business in Texas as 130 Environmental Park, LLC” (*Ex. 130EP-1, p.50*) and, in accordance with TCEQ’s rule at 30 TAC §330.59(e), includes verification of legal status in the form of a Certificate of Fact regarding 130 Environmental Park, LLC issued by the Texas Secretary of State that includes a certification that “the entity status in Texas is in existence”. 130 Environmental Park, LLC is a legal entity separate and distinct from Green Group Holdings, LLC (the sole member and 100% owner of 130 Environmental Park, LLC). Because 30 TAC §330.59(f)(1) and (2) require the “owner or operator” to submit information about other solid waste sites owned or operated by the owner or operator with in the last ten years and information about other solid waste sites in which the owner or operator has a direct financial interest, the Application correctly states that 130 Environmental Park, LLC (the operator) “does not own or operate other facilities in Texas” and “has no financial interests outside the state of Texas” (*Ex. 130EP-1, p.50*). Because Green Group Holdings, LLC is (and will be) neither the owner nor the operator of the proposed 130 Environmental Park facility<sup>6</sup>, no information regarding it is required by 30 TAC §330.59(f)(1) and (2), and information regarding Green Group Holdings, LLC would not be responsive to the information required by 30 TAC §330.59(f)(1) and (2)<sup>7</sup>.

---

<sup>6</sup> Statutory provisions in the Texas Business Organizations Code confirm that, even after 130 Environmental Park, LLC purchases the property on which the 130 Environmental Park facility will be located, Green Group Holdings, LLC will not have an ownership interest in that property and, thus, will not be an “owner” pursuant to TCEQ municipal solid waste rules. Section 101.106(b) of the Texas Business Organizations Code provides, “A member of a limited liability company...does not have an interest in any specific property of the company”, and Section 9.202 of the Texas Business Organizations Code provides, “a foreign filing entity registered under this chapter enjoys the same but no greater rights and privileges as the domestic entity to which it most closely corresponds”.

<sup>7</sup> In addition, despite TJFA/EPICC’s claim (at page 14 of their Response to Closing Arguments) regarding “other landfills owned by Green Group Holdings”, Green Group Holdings, LLC does not own any landfills, nor does it own or operate any solid waste sites.

**H. TJFA/EPICC assertion:** “Nor were all of Green Group Holdings’ environmental permits listed, as required by Rule 305.45(a)(8).”

**Response:** The rule provision cited by TJFA/EPICC (30 TAC §305.45(a)(8)) does not require information about environmental permits; it addresses a supplementary technical report that is required to be included with an application (and that is included in 130 Environmental Park, LLC’s permit application at Part I, Section 1.2, *Ex. 130EP-1 pp.43-45*). The preceding rule subsection, 30 TAC §305.45(a)(7), requires that a permit application include:

a listing of all permits or construction approvals received or applied for under any of the following programs:

(A) Hazardous Waste Management Program under the Texas Solid Waste Disposal Act;

(B) Underground Injection Control Program under the Texas Injection Well Act;

(C) National Pollutant Discharge Elimination System Program under the Clean Water Act and Waste Discharge Program under Texas Water Code, Chapter 26;

(D) Prevention of Significant Deterioration Program under the Federal Clean Air Act (FCAA);

(E) Nonattainment Program under the FCAA;

(F) national emission standards for hazardous air pollutants preconstruction approval under the FCAA;

(G) ocean dumping permits under the Marine Protection Research and Sanctuaries Act;

(H) dredge or fill permits under the FCAA;

(I) licenses under the Texas Radiation Control Act;

(J) subsurface area drip dispersal system permits under Texas Water Code, Chapter 32; and

(K) other environmental permits

It is clear from the context of this subsection that it refers to other environmental “permits or construction approvals received or applied for” at the same location as the permit being sought. It certainly does not require 130 Environmental Park, LLC to list permits or construction approvals received or applied for by any other entity. In addition, Green Group Holdings, LLC does not hold and has not received or applied for any environmental (or other) permits or construction approvals.

**I. TJFA/EPICC assertion:** “The site operating plan in the Application calls for a 40,000-pound trash compactor to ‘minimize future consolidation and settlement, and provide for the application of intermediate and final cover.’ At the hearing, however, when the Applicant’s expert on odor was asked on cross whether the Applicant’s odor management plan addressed the odor emanating from the trash compactor, Applicant’s attorney made a statement and judicial admission: ‘There’s no trash compactor proposed for this facility.’ The seemingly arbitrary conflict between in-hearing admissions and the contents of the Application undermines the Applicant’s contention in its Closing Statement that the Application contains the number and size of each type of equipment to be dedicated to facility operations.”

**Response:** The line of questions regarding a “trash compactor” posed during the hearing by TJFA/EPICC attorney Brad Rockwell to Martha O’Brien, 130 Environmental Park, LLC’s expert witness on odors, was:

Q Can odor emanate from a trash compactor?

A To some degree, some degree of odor could, depending upon what's in it.

Q And are there circumstances where a trash -- the amount -- the intensity of odor from a trash compactor can be quite large?

A I suppose it could, but the quantity of that odorous air would be quite small.

Q Where does 130 Environmental Park's odor management plan address the odor emanating from trash compactors?

A I don't know if it does; but, again, that would not be a major source of odor that I would be worried about.

Q Do you know where the trash compactor is to be located under the terms of this permit?

(Tr. p.991/l.12-p.992/l.2). A “stationary compactor” is a large, enclosed piece of equipment into which waste is placed and mechanically compacted to reduce its volume. A stationary compactor would be set up at and operated at a particular location, typically at a shopping center, apartment complex, etc., where waste material would be placed into it for compaction to reduce its volume before the waste is transported to a landfill for disposal. An example of a stationary compactor is shown on Attachment 2. TCEQ’s municipal solid waste rules address stationary compactors, and odors associated with them, at 30 TAC §330.215, “Requirements for Stationary Compactors”, which provides, in part: “Stationary compactors shall be operated and maintained in such a way as not to create a public nuisance through material loss or spillage, odor, vector breeding or harborage, or other condition.” It is clear that the questions and answers set out above were addressing a stationary compactor: Ms. O’Brien’s first answer includes “depending on what’s in it”, Mr. Rockwell’s third question asked where the Odor Management Plan in 130 Environmental Park’s permit application addressed the “odor emanating from trash compactors”, and Mr. Rockwell’s last question asked about “where the trash compactor is to be located”. The undersigned attorney for 130 Environmental Park, LLC, realizing that a question about where a “trash compactor” was proposed to be located was obviously a reference to a stationary compactor, objected to the last question on relevance grounds, stating, “There's no trash compactor proposed for this facility...He's asking about something that doesn't exist.” Neither Mr. Rockwell’s questions, nor Ms. O’Brien’s answers, nor the undersigned’s objection and statements in support of it, were referring to the “CAT 836” compactor(s) described in the Application: a piece of mobile, wheeled, heavy equipment that is driven over waste after it has been placed in a landfill to reduce its in-place volume. A “CAT 836” is shown in Attachment 3. Obviously, waste is not placed into a CAT 836 and there would not be a place on the 130 Environmental Park Landfill where it would be “located”. In addition, TCEQ’s municipal solid waste rules do not address odors associated with this sort of heavy equipment. In making the objection to Mr. Rockwell’s last question set out above, the undersigned was asserting the lack of relevance to questioning about a stationary compactor, not suggesting that a CAT 836 would not be used at the landfill. The Application correctly lists the “the number and size of each type of equipment to be dedicated to facility operation”, including one or two CAT 836s, as required by 30 TAC §330.59(f)(5). (*Ex. 130EP-1, p.52*).

referring to the "CAT 836" compactor(s) described in the Application: a piece of mobile, wheeled, heavy equipment that is driven over waste after it has been placed in a landfill to reduce its in-place volume. A "CAT 836" is shown in Attachment 3. Obviously, waste is not placed into a CAT 836 and there would not be a place on the 130 Environmental Park Landfill where it would be "located". In addition, TCEQ's municipal solid waste rules do not address odors associated with this sort of heavy equipment. In making the objection to Mr. Rockwell's last question set out above, the undersigned was asserting the lack of relevance to questioning about a stationary compactor, not suggesting that a CAT 836 would not be used at the landfill. The Application correctly lists the "the number and size of each type of equipment to be dedicated to facility operation", including one or two CAT 836s, as required by 30 TAC §330.59(f)(5). (*Ex. 130EP-1, p.52*).

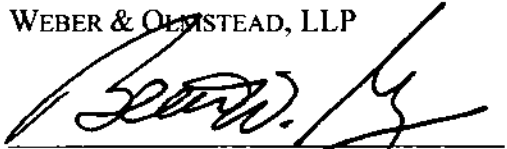
**Prayer**

WHEREFORE, premises considered, 130 Environmental Park respectfully requests that the ALJs prepare a Proposal for Decision (1) recommending the granting of a permit to 130 Environmental Park with the provisions as set out in the Draft Permit prepared and recommended by the TCEQ Executive Director, (2) including as proposed findings of fact and conclusions of law those set out in Applicant's Amended Proposed Findings of Fact and Conclusions of Law (Attachment 3 to Applicant's Response to Closing Arguments), and (3) recommending assessment of reporting and transcription costs as set out in Section A.32 of Applicant's Response to Closing Arguments.

Respectfully submitted,

MC ELROY, SULLIVAN, MILLER,  
WEBER & OLIVESTEAD, LLP


By:

  
Brent W. Ryan  
State Bar No. 17469475  
P.O. Box 12127  
Austin, TX 78711  
Tel: (512) 327-8111  
Fax: (512) 327-6566

Attorneys for  
130 Environmental Park, LLC

**CERTIFICATE OF SERVICE**

On December 22, 2016, a true and correct copy of the foregoing was sent to each party representative via email and/or first-class mail, as shown on the attached service list. In addition, a Word version of the foregoing document was submitted to Ms. Hilary Aguirre at Hilary.Aguirre@soah.texas.gov.

  
Brent W. Ryan

**SERVICE LIST**

SOAH Docket No. 582-15-2082; TCEQ Docket No. 2015-0069-MSW  
Application of 130 Environmental Park Landfill, LLC for Proposed Permit No. 2383

Kayla Murray *via email kayla.murray@tceq.texas.gov*  
Anthony Tatu *via email anthony.tatu@tceq.texas.gov*  
Aaron Vargas *via email Aaron.Vargas@Tceq.Texas.Gov*  
Texas Commission on Environmental Quality  
Environmental Law Division  
P.O. Box 13087, MC-173  
Austin, TX 78711-3087  
**Attorneys for TCEQ Executive Director**

Aaron Tucker *via email aaron.tucker@tceq.texas.gov*  
Texas Commission on Environmental Quality  
Office of Public Interest Counsel  
P.O. Box 13087, MC-103  
Austin, TX 78711-3087  
**Attorney for TCEQ Office of Public Interest Counsel**

Eric Magee *via email e.magee@allison-bass.com*  
Allison, Bass & Magee, LLP  
402 W. 12th Street  
Austin, TX 78701  
Fax: (512) 480-0902  
**Attorney for Caldwell County, Texas**

Robert Wilson *via email bwilson@jacksonsjoberg.com*  
Jackson, Sjoberg, McCarthy & Townsend, LLP  
711 W. 7th Street  
Austin, TX 78701  
**Attorney for Plum Creek Conservation District**

Marisa Perales *via email marisa@lf-lawfirm.com*  
Eric Allmon *via email eallmon@lf-lawfirm.com*  
Brad Rockwell *via email brad@lf-lawfirm.com*  
Frederick, Perales, Allmon & Rockwell, PC  
707 Rio Grande, Suite 200  
Austin, TX 78701  
**Attorneys for TJFA, L.P. and Representatives for Aligned Protestants**

Ben Pesl *via First-Class Mail*  
P.O. Box 242  
Dale, TX 78616

**Implementation Plan for the  
Development of Synthetic Unit Hydrographs  
By  
NWS/NOHRSC**

**Soil Conservation Service  
Dimensionless Unit Hydrograph**

**Soil Conservation Service - Dimensionless Unit Hydrograph**

The Soil Conservation Service (SCS) dimensionless unit hydrograph procedure is one of the most well known methods for deriving synthetic unit hydrographs in use today. References for this method can be found in most hydrology textbooks or handbooks. The primary reference for this method may be considered as the Soil Conservation Service - *National Engineering Handbook, Section 4, Hydrology* (SCS 1972). There are a number of versions of this reference occurring both before and after the given date. The dimensionless unit hydrograph used by the SCS was developed by Victor Mockus and was derived based on a large number of unit hydrographs from basins which varied in characteristics such as size and geographic location. The unit hydrographs were averaged and the final product was made dimensionless by considering the ratios of  $q/q_p$  (flow/peak flow) on the ordinate axis and  $t/t_p$  (time/time to peak) on the abscissa, where the units of  $q$  and  $q_p$  are flow/inch of runoff/unit area. This final, dimensionless unit hydrograph has a time-to-peak located at approximately 20% of its time base and an inflection point at 1.7 times the time-to-peak. The dimensionless unit hydrograph is illustrated in Figure 1. Figure 1 also illustrates the cumulative mass curve for the dimensionless unit hydrograph. Table 1 provides the ratios for the dimensionless unit hydrograph and the corresponding mass curve.

**Development**

The curvilinear unit hydrograph may also be represented by an equivalent triangular unit hydrograph. Figure 2 illustrates the equivalent triangular unit hydrograph. Recall that the unit hydrograph is the result of 1-inch of excess rainfall (of duration  $D$ ) spread uniformly over the basin. This 1-inch of excess rainfall is also indicated in Figure 2 to aid in the definition of the timing parameters which will be discussed momentarily. Using the geometry of the triangles, one can see that the unit hydrograph has 37.5% (or 3/8) of its volume on the rising side and the remaining 62.5% (or 5/8) of the volume on the recession side. Using the dimensionless timing values on the x-axis, one can solve for the time base in terms of the time-to-peak.

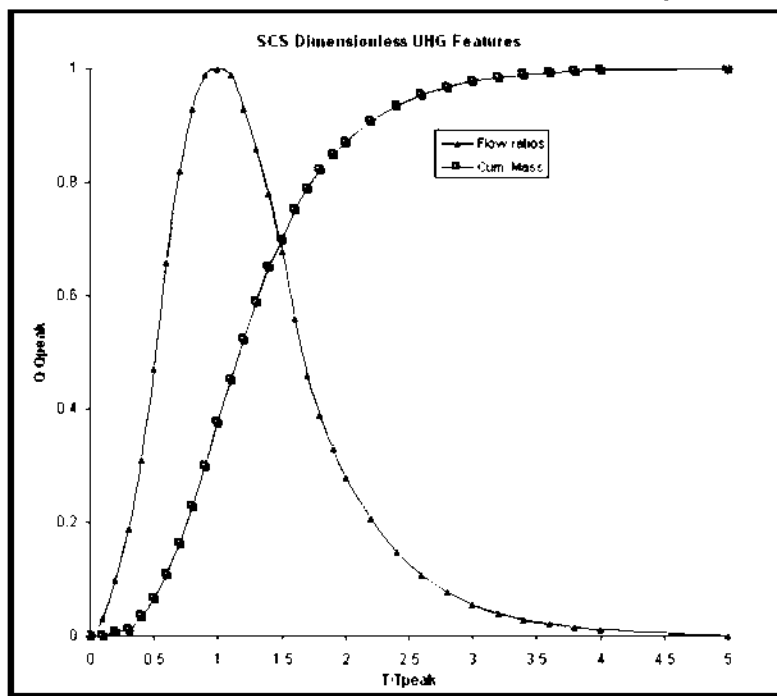


Figure 1 - SCS Dimensionless unit hydrograph and mass curve

Table 1 - Ratios for dimensionless unit hydrograph and mass curve.

Time Ratios ( $t/t_p$ )	Discharge Ratios ( $q/q_p$ )	Mass Curve Ratios ( $Q_a/Q$ )	Time Ratios ( $t/t_p$ )	Discharge Ratios ( $q/q_p$ )	Mass Curve Ratios ( $Q_a/Q$ )
0	.000	.000	1.6	.560	.751
.1	.030	.001	1.7	.460	.790
.2	.100	.006	1.8	.390	.822
.3	.190	.012	1.9	.330	.849
.4	.310	.035	2.0	.280	.871
.5	.470	.065	2.2	.207	.908
.6	.660	.107	2.4	.147	.934
.7	.820	.163	2.6	.107	.953
.8	.930	.228	2.8	.077	.967
.9	.990	.300	3.0	.055	.977

1.0	1.000	.375
1.1	.990	.450
1.2	.930	.522
1.3	.860	.589
1.4	.780	.650
1.5	.680	.700

3.2	.040	.984
3.4	.029	.989
3.6	.021	.993
3.8	.015	.995
4.0	.011	.997
4.5	.005	.999
5.0	.000	1.000

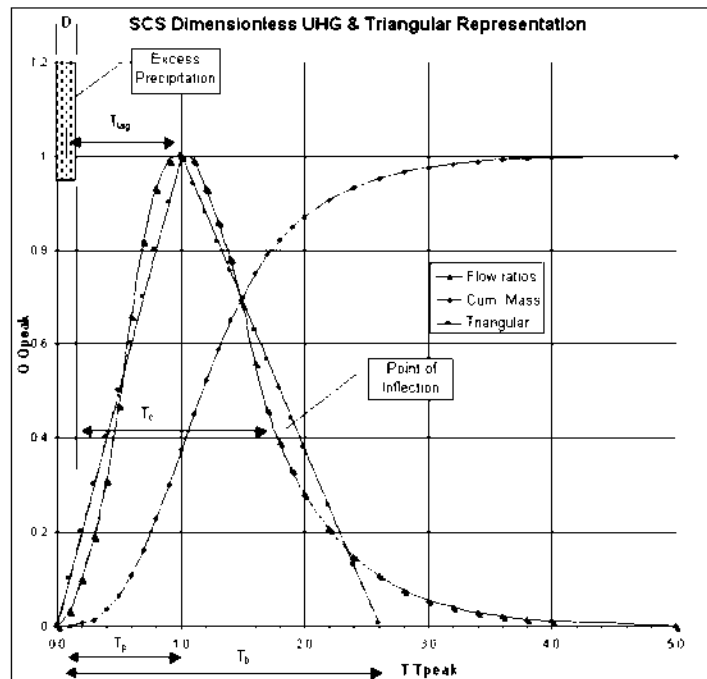


Figure 2 - Illustration of dimensionless curvilinear unit hydrograph and equivalent triangular hydrograph.

The following relationships are made and will be useful in further developing the peak rate relationships.

$$T_b = 2.67 \times T_p \quad \text{Equation 1}$$

and

$$T_r = T_b - T_p = 1.67 \times T_p \quad \text{Equation 2}$$

Again using the geometric relationships of the triangular unit hydrograph of Figure 2, the total volume under the hydrograph is found by:

$$Q = \frac{q_p T_p}{2} + \frac{q_p T_r}{2} = \frac{q_p}{2} (T_p + T_r) \quad \text{Equation 3}$$

The volume,  $Q$ , is in inches and the time,  $T$ , is in hours. The peak rate,  $q_p$ , in inches per hour, is found to be :

$$q_p = \frac{2Q}{T_p + T_r} \quad \text{Equation 4}$$

The term,  $q_p$ , in the above equation is converted to cubic feet per second and the drainage area,  $A$  ( $\text{mi}^2$ ), is brought into the equation, which results in :

$$q_p = \frac{654.33 \times 2 \times A \times Q}{T_p + T_r} \quad \text{Equation 5}$$

The 645.33 is the conversion used for delivering 1-inch of runoff (the area under the unit hydrograph) from 1-square mile in 1-hour (3600 seconds). Substituting in relationships developed in equation 1 above, equation 5 is rewritten :

$$q_p = \frac{484 A Q}{T_p} \quad \text{Equation 6}$$

Because the above relationships were developed based on the volumetric constraints of the triangular unit hydrograph, the equations and conversions are also valid for the curvilinear unit hydrograph, which, proportionally, has the same volumes as the triangular representation. The conversion constant (or peaking factor) 484 is the result of the large number of unit hydrographs from a wide range of basin characteristics and actually reflects the ability of the watershed to retain and delay the flow. This constant may not be applicable to all watershed types.

Steep terrain and urban areas may tend to produce higher early peaks and thus values of the peaking factor may tend towards 600. Likewise, flat swampy regions tend to retain and store the water, causing a delayed, lower peak. In these circumstances values may tend towards 300 or lower (SCS 1972; Wanielista, et al. 1997). It would be very important to document any reasons for changing the constant from 484, effectively changing the shape of the unit hydrograph. When changing the shape of the unit hydrograph, one must keep in mind the ratios of the volumes under the rising and falling sides of the original dimensionless unit hydrograph and the resulting volume under the unit graph must remain at 1 inch. Table 2 illustrates possible values for the peaking factor and the associated ratios of recession limb length to rising limb. Table 2 does not include a reference value for swampy regions; however, this would be a rather low value, as well. Again, it is important to note that experience and judgment are very important in determining the most appropriate values for a region.

**Table 2 - Hydrograph peaking factors and recession limb ratios (Wanielista, et al. 1997)**

General Description	Peaking Factor	Limb Ratio (Recession to Rising)
Urban areas; steep slopes	575	1.25
Typical SCS	484	1.67
Mixed urban/rural	400	2.25
Rural, rolling hills	300	3.33
Rural, slight slopes	200	5.5
Rural, very flat	100	12.0

The peak rate may also be expressed in terms of other timing parameters besides the time-to-peak. From Figure 2 :

$$T_p = \frac{D}{2} + L \quad \text{Equation 7}$$

where  $D$  = the duration of the unit excess rainfall and  $L$  = the basin lag time, which is defined as the time between the center of mass of excess rainfall and the time to peak of the unit hydrograph. The peak flow is now written as

$$q_p = \frac{484 A Q}{\frac{D}{2} + L} \quad \text{Equation 8}$$

The SCS (1972) relates the lag time,  $L$ , to the time of concentration,  $T_c$  by :

$$L = 0.6 * T_c \quad \text{Equation 9}$$

Combining this with other relationships, as illustrated in the triangular unit hydrograph, the following relationships develop:

$$T_c + D = 1.7 T_p \quad \text{Equation 10}$$

and

$$\frac{D}{2} + 0.6 T_c = T_p \quad \text{Equation 11}$$

From this, the duration  $D$  may be expressed as:

$$D = 0.133 T_c \quad \text{Equation 12}$$

Equation 11 provides a desirable relationship between duration and time of concentration, which will provide enough points accurately represent the unit hydrograph, particularly the rising limb.

The peak flow rate could now be expressed in terms of the time of concentration as :

$$q_p = \frac{726 A Q}{T_c} \quad \text{Equation 13}$$

As a final note, for a unit hydrograph, the volume of runoff,  $Q$ , would be equal to 1-inch.

### Application of SCS Unit Hydrograph

It is necessary to estimate the lag time for a given basin (of area,  $A$ ) in order to derive the SCS dimensionless unit hydrograph. The timing parameter is somewhat difficult to estimate and rather subjective; however, this parameter has considerable influence on the values of the unit hydrograph. Before addressing timing parameters, the process of estimating areas will be noted.

**Area Estimation :**

Suffice it to say that the drainage area,  $A$ , should be obtained with as much accuracy and precision as is feasibly possible. Within the context of the planned implementation, the area will already have been estimated as part of the IHABBS package. For the basins typically to be encountered by the RFCs and WFOs, the (approximately) ½ kilometer data should provide areas within a few percent. The accuracy may be somewhat less for more flat areas.

**Timing Parameter(s) :**

The 2 methods to be considered are to be known as : 1) the SCS lag equation (using the SCS curve number) and 2) a segmental velocity approach.

**SCS Lag Approach**

The SCS lag method is an empirical approach developed by the SCS to estimate the lag time or the distance from the center of mass of excess rainfall to the peak discharge. The SCS (1972) provides . The SCS also recommends that the lag equation be used on basins that may be considered somewhat homogeneous in nature and basins that are less than 2000 acres in size. Due to these restrictive recommendations, the method may be rather limited in application to most of the basins expected to be part of the WHFS system of modeling locations; however, due to the relative ease of estimation and the potential for having smaller basins, this method will be included. Restrictions on the use of the lag equation should be stated, although some leeway beyond the 2000 acre size limit may later be found justifiable. The SCS lag equation is given as :

$$T_{lag} = \frac{L^{0.8}(S + 1)^{0.7}}{1900(\%Slope)^{0.5}} \quad \text{Equation 14}$$

where :  $T_{lag}$  = lag time in hours

$L$  = Length of the longest drainage path in feet

$S = (1000/CN) - 10$  (CN=curve number)

$\%Slope$  = The average watershed slope in %

It will be necessary to derive the SCS curve number (CN); however, this is a planned activity, as part of the WHFS implementation. The reader is referred to the SCS Curve Number Section for implementation plans. The remaining parameters are the Length,  $L$ , and the % Slope. The length,  $L$  is the length of the longest drainage path from the watershed outlet to the watershed divide, which is generally obvious for most watersheds. The more difficult parameter is the average slope of the watershed. This is a rather subjective parameter, as it is highly dependent on the viewpoint of the user. It is generally insufficient to use the slope of the longest drainage path as this will usually produce a more mild slope and is not representative of the near stream areas which may have considerably higher slopes and cause faster responses. The impact of a low value for slope is to produce a larger lag time, as can be seen from equation 13. The longer lag time has the effect of reducing the peak of the unit hydrograph as can be seen from equations 6 and 12.

In the planned implementation, there exists a slope GIS layer or coverage. This ½ kilometer data set is the result of averaging the slopes of a 90m DEM (1:250,000) within each ½ kilometer cell. The average slope of the watershed, for small (say <5 square miles) watersheds would be the average of the ½ kilometer cells in the respective basin. Lindsey,

Kohler, and Paulhus (1949) provide a means of estimating the average watershed slope that involves overlaying a grid on the basin, which has been sketched on a topographic map. The average slope is found by :

$$\%Slope = \frac{N\Delta Z}{l} * 100 \quad \text{Equation 15}$$

where  $N$  = total number of contour crossings on the grid lines,  $DZ$  = the contour interval and  $l$  = the length of all the grid lines. In a GIS, there is a grid already associated with the DEM, thus the average slope could be calculated by summing the number of potential contour crossings on each row and column. The contour interval should be the expected accuracy of the DEM (i.e. 5 meters in the vertical). There is the potential problem of the contour lines not being perpendicular to the rows and columns. Horton (1926) suggested the average slope could be calculated by :

$$\%Slope = \frac{N\Delta Z \sec \theta}{l} * 100 \quad \text{Equation 16}$$

where  $q$  = the angle between the contours and the grid lines (rows and columns). Due to the difficulty in evaluating  $q$ , Horton suggested that an average value of  $\sec q = 1.571$  could be used. Thus equation 15 could be written:

$$\%Slope = \frac{N\Delta Z * 157.1}{l} \quad \text{Equation 17}$$

### Segmental Approach

In the segmental velocity or segmental approach, the parameter being estimated is essentially the time of concentration or longest travel time within the basin. In general, the longest travel time corresponds to the longest drainage path; however, there may be situations and basin configurations that allow for some shorter travel distances to have longer travel times, due to roughness and/or flow type. The flow path is broken into segments with the flow in each segment being represented by some type of flow regime. The most common flow representations are overland, sheet, rill and gully, and channel flow. A number of equations or graphs are available to estimate the travel velocity of surface flow in each type of condition. The travel times are then estimated by dividing the segment length by the associated velocity. The sum of all of the travel times represents the time of concentration. The relationship between time of concentration and lag time is given by Equation 9.

The velocities in each segment may be calculated by a number of means. For channel segments, the velocity could be estimated via the Manning equation :

$$V = \frac{1.49}{n} R_h^2/3 S^{1/2} \quad \text{Equation 18}$$

where  $V$  = velocity,  $n$  = Manning roughness coefficient,  $R_h$  = hydraulic radius,  $S$  = slope in ft/ft. This would require knowledge of the channel parameters and/or shapes for the basin in question. An equation similar in form to the Manning equation may be recommended :

$$V = kS^{1/2} \quad \text{Equation 19}$$

where  $k$  is a coefficient based on the flow type. McCuen (1989) and SCS (1972) provide values of  $k$  for several flow situations. The values of  $K$  are assuming that slope is given in percent.

**Table 3 - Coefficients of velocity (fps) versus slope (%) relationship for estimating travel velocities (McCuen 1989; SCS 1972).**

$K$	Land Use / Flow Regime
-----	------------------------

0.25	Forest with heavy ground litter, hay meadow (overland flow)
0.5	Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland (overland flow)
0.7	Short grass pasture (overland flow)
0.9	Cultivated straight row (overland flow)
1.0	Nearly bare and untilled (overland flow); alluvial fans in western mountain regions
1.5	Grassed waterway
2.0	Paved area (sheet flow); small upland gullies

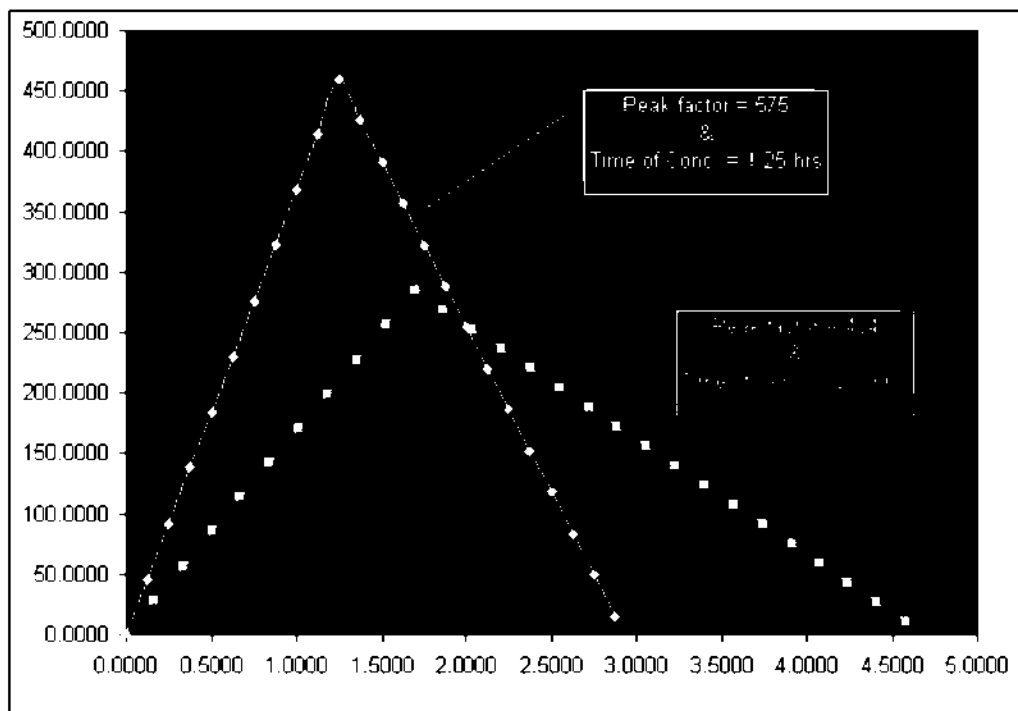
The Michigan Department of Natural Resources (Sorrell and Hamilton 1991) - Land and Water Management Division (1991) provide very similar relationships as illustrated in Table 4.

**Table 4 - Coefficients of velocity (fps) versus slope (%) relationship for estimating travel velocities (Sorrell and Hamilton 1991).**

Flow Type	K
<i>Small Tributary</i> - Permanent or intermittent streams which appear as solid or dashed blue lines on USGS topographic maps.	2.1
<i>Waterway</i> - Any overland flow route which is a well defined swale by elevation contours, but is not a stream section as defined above.	1.2
<i>Sheet Flow</i> - Any other overland flow path which does not conform to the definition of a waterway.	0.48

#### Example 1 :

An example of a hypothetical unit hydrographs derived from a 1 square mile basin. The time of concentration and peaking factor were altered to simulate the effect of "urbanizing" the basin. A peaking factor of 484 and time of concentration were assigned for the original condition. Urbanization may tend to cause a shorter time of concentration and a higher peaking factor. The resulting triangular unit hydrographs are shown in Figure 3.



**Figure 3 - Triangular unit hydrographs for hypothetical 1 mi<sup>2</sup> basin before and after "urbanization".**

### Triangular Shape

There is some concern about a "triangular" unit hydrograph. In general, it can be said that the triangular version will not cause or introduce noticeable differences in the simulation of a storm event, particularly when one is concerned with the peak flow. For long term simulations, the triangular unit hydrograph does have a potential impact, due to the shape of the recession limb. In order to account for this, it is possible to "fit" a more curvilinear unit hydrograph by several means. The U.S. Army Corps of Engineers (HEC 1990) fits a Clark unit hydrograph to match the peak flows estimated by the Snyder unit hydrograph procedure, which is essentially a trial and error procedure. It is also possible to fit a synthetic or mathematical function to the peak flow and timing parameters of the desired unit hydrograph.

Aron and White (1982) fitted a gamma probability distribution using peak flow and time to peak data. The gamma distribution is :

$$f(t, a, b) = \frac{t^a e^{-t/b}}{b^{a+1} \Gamma(a+1)} \quad \text{Equation 20}$$

McCuen (1989) provides a procedure for implementation of this method :

1. Compute :

$$f_a = \frac{q_p t_p}{A} \quad \text{Equation 21}$$

where :

$q_p$  = peak flow in cfs

$t_p$  = time to peak in hours

$A$  = drainage area in acres

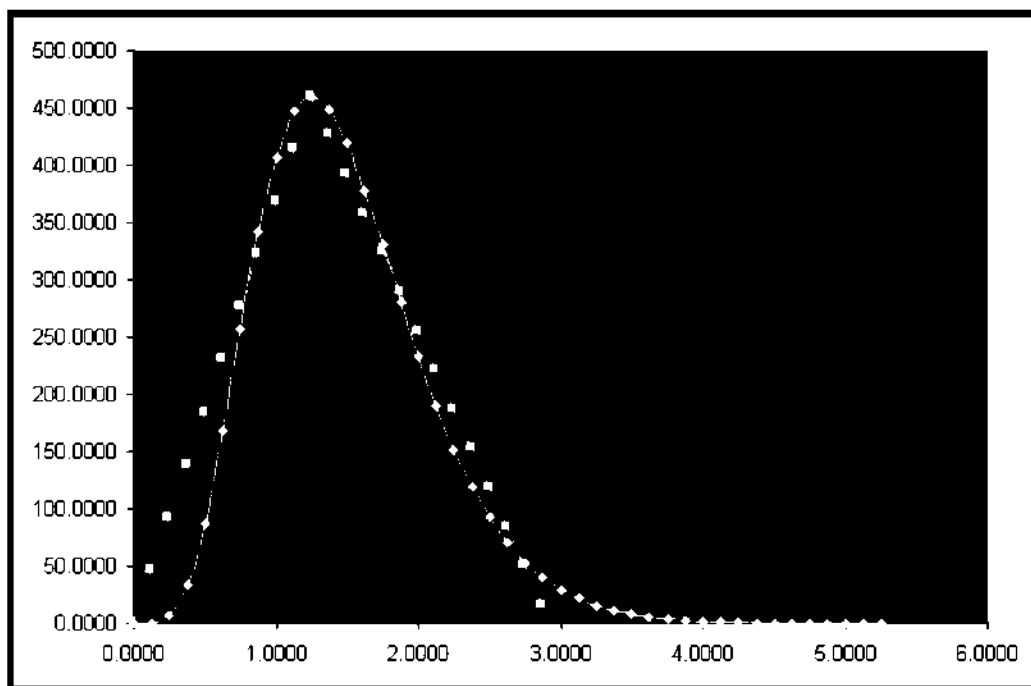
2. Find the value of "a" from the following :

$$a = 0.045 + 0.5f_a + 5.6f_a^2 + 0.3f_a^3 \quad \text{Equation 22}$$

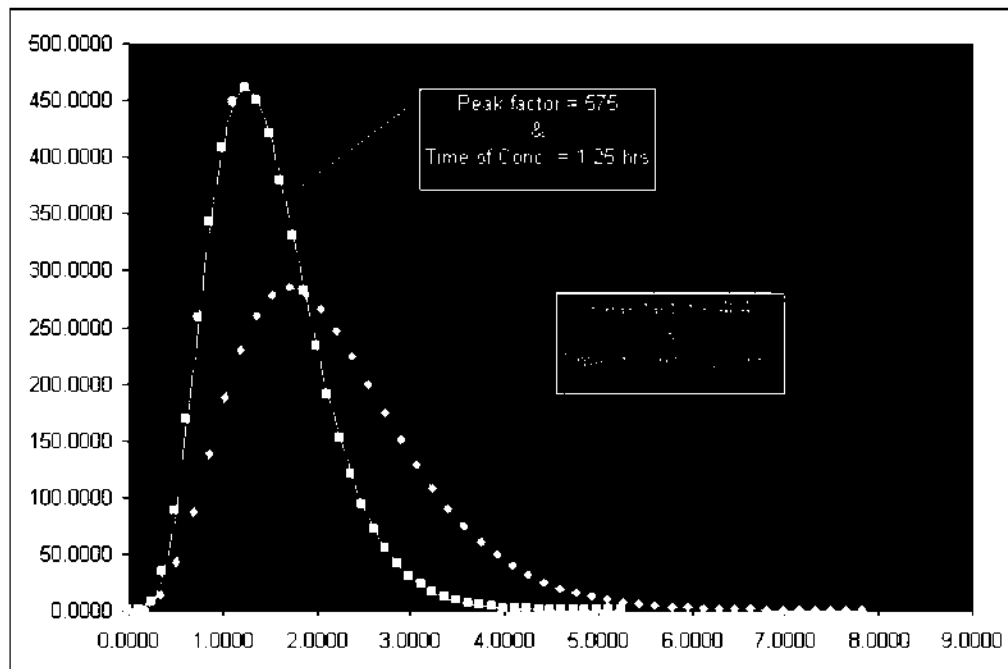
3. The ordinates of the unit hydrograph from :

$$q(f) = q_p f^a e^{-af} \quad \text{Equation 23}$$

Figure 4 illustrates fitting of the gamma distribution to the triangular unit hydrograph (pre-urban) of example 1 illustrated in Figure 3.



**Figure 4 - Gamma fitted distribution of the pre-urban triangular unit hydrograph is example 1.**



**Figure 5 - Comparison of the gamma fitted unit hydrographs for example 1.**

## Conclusions

The following items, in no particular order of importance, must be considered when deriving the SCS unit hydrograph:

1. Slope - The slope is the average slope of the basin. This is somewhat of a concern as the response time may not be well represented by the average slope or the contributing area(s) may be smaller than the overall basin area and may be associated with a higher value of the average slope.
2. The constant 484 in the equation for peak flow of the unit hydrograph - As mentioned this may not be applicable for all areas of the country. This will require input from an experienced hydrologist to determine the most appropriate values for various basins. A default value of 484 will be used.
3. Duration - The duration of the unit hydrograph plays a role in determining the peak flow via the time to peak (equation 7). Equation 11 provides guidance for determining a value of the duration, and hence the computational timestep, such that there are sufficient points on the rising side of the unit hydrograph to adequately represent and simulate runoff from a precipitation event.
4. Triangular Shape - A triangular unit hydrograph is produced. The triangular unit hydrograph represents 1-inch of excess precipitation (the volume under the unit hydrograph). While the curvilinear unit hydrograph is more traditional in shape; there will be minimal difference in the overall simulation capabilities between the two unit hydrographs. This is particularly true for single event simulations.

## Overview of Computations

Table 5 provides a description of the required user inputs for the SCS method, while Table 6 provides an overview of the

steps that will be completed for during the derivation of the SCS unit hydrograph for each basin, as part of the planned implementation and Table 7 provides a description of the segmental approach to estimating the time of concentration.

**Table 5 - Required user inputs for SCS dimensionless unit hydrograph method.**

Parameter	Default Value	Comments
Peaking Factor	484	May vary widely depending on terrain, basin characteristics, etc.
Duration(s)	1 hour	The default will be 1 hour; however, the user will be able to request any or several durations to be calculated.
Method of Estimating Lag Time	Segmental Approach	The segmental approach will be used unless the user selects the SCS lag method (Equation 14). Refer to Table 7 for a more thorough description of the segmental approach.

**Table 6 - Steps for determining the time of concentration in the planned implementation.**

Step	Description
1	Determine cell flow length. If cell flows left, right, up, or down then length is equal to grid size (~ 1/2 km). If cell flows diagonally, then length is grid size x $\sqrt{2}$ .
2	Determine cell slope.
3	Determine travel velocity through cell via Equation 19. If cell is a boundary cell (i.e. first cell on the flow path to the outlet), then first 15 meters will have a velocity coefficient of 0.5, the remaining length (cell length - 15 meters) will use a velocity coefficient of 1.2. Any cell which is NOT a boundary cell will either be defined as a channel cell or non-channel cell. The IHABBS data sets include EPA RFI stream data and thus cells will be able to be differentiated. Non-channel cells will use a coefficient of 1.2 and channel cells will use a coefficient of 2.1
4	The longest travel time to the outlet is determined and is considered to be the time of concentration.

NOTE : It may be necessary to allow the user to assign velocity coefficients.

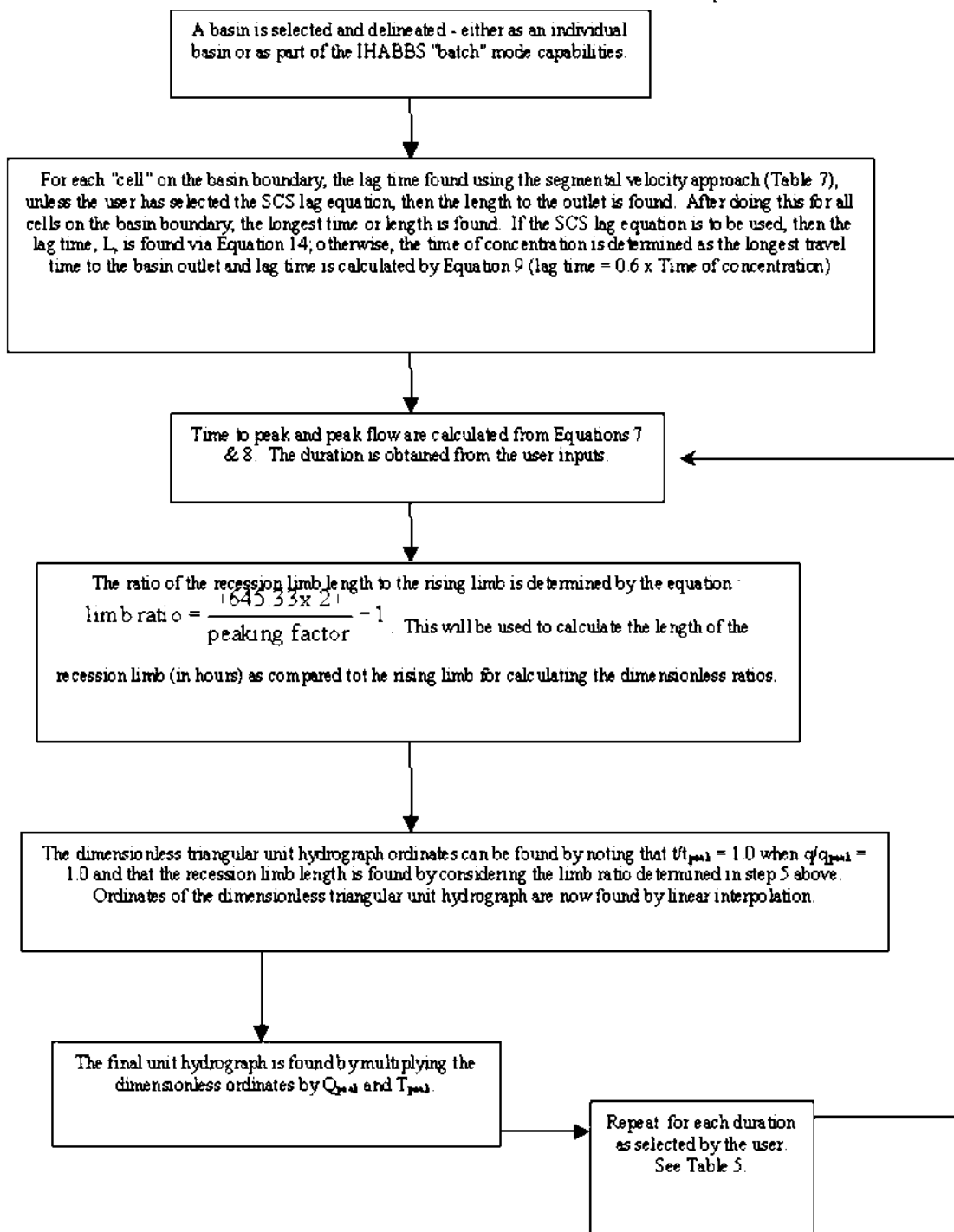


Figure 6 - Computational flow diagram for SCS segmental approach.

## References

- Aron, G. and E. White, 1982. Fitting a Gamma Distribution Over a Synthetic Unit Hydrograph, Water Resources Bulletin, Vol. 18(1) 95-98, Feb. 1982.
- McCuen, R. H. 1989. Hydrologic Analysis and Design. Prentice-Hall, Inc. Englewood Cliffs, NJ.
- Sorrell, Richard C. and David A Hamilton, 1991. Computing Flood Discharges for Small Ungaged Watersheds, Michigan Department of Natural Resources - Land and Water Management Division.
- SCS, 1972 - (Soil Conservation Service). National Engineering Handbook, Section 4, U.S. Department of Agriculture, Washington, D.C.

Wanielista, Martin, Robert Kersten, & Ron Eaglin, 1997. Hydrology : Water Quantity and Quality Control, 2<sup>nd</sup> Edition, Wiley and Sons, Inc., New York, NY.



## STATIONARY COMPACTOR



**Which equipment is right for you?**

**CONTACT US TODAY**

## REDUCE HAULAGE FREQUENCY & COSTS

Our single cylinder stationary compactor has been created specifically for the toughest applications. Feed capacities, compaction force, and loading options can be adjusted to suit your specific needs.



