Lady Bird (Town) Lake Benthic Macroinvertebrate Study

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Lady Bird (Town) Lake is a reservoir located on the Colorado River within the city limits of Austin, TX. It is the last reservoir in the chain of Highland Lakes. The City of Austin Watershed Protection and Development Review Department routinely monitors water quality on Lady Bird Lake, but has never monitored benthic macroinvertebrates in the lake. In 2004 a pilot study was initiated to determine if long term monitoring of benthic macroinvertebrates was useful, and if so were there particular seasons (release vs. non-release) to focus monitoring. Three areas of the lake were targeted as representative: un-impacted by urban streams (MoPac site), impacted by urban streams (IH-35 site), and lacustrine or "lake-like" (Basin site). The study ran from September 2004-March 2007, with an additional sample taken in April 2007 to assess targeted habitats. Future macroinvertebrate surveys of Lady Bird Lake should occur during release period to obtain higher total taxa and abundance. The three transect locations adequately represent the different areas of the lake, but additional sampling at sites in April 2007 add beneficial information from different available habitats in the lake. Sublittoral (deeper) samples produced very little total taxa and abundances were low; all taxa present in these samples were collected from north and south littoral (shoreline) samples. Overall 84 taxa were collected from Lady Bird Lake representing both insect and non-insect benthic macroinvertebrates. While a majority of taxa (73%) were insect taxa, invertebrate abundance was dominated (71%) by non-insect taxa.

Introduction

Lady Bird Lake is a 5.4 mile long reservoir, and is the last reservoir in the chain of Highland Lakes along the Colorado River. Lady Bird Lake was formed from the construction of the Longhorn Dam, which began in April 1959 and was completed in September 1960. The lake is held at a constant level (428-429 feet in elevation) and is used as a "pass through" reservoir. The lake is located within the city limits of Austin, Texas and is surrounded by areas dedicated as greenbelts and parks, as well as commercial and residential real-estate (TWDB 1999).

Benthic (bottom living) macroinvertebrates are common inhabitants of lakes and streams where they are important in moving energy through food webs. Benthic organisms usually inhabit benthic substrates for at least part of the life cycle. The term macro indicates that these organisms are generally retained by mesh sizes of approximately 500µm (micrometers) and are generally >1mm in length. Benthic macroinvertebrates are a highly diverse group, with varied tolerances to pollution, which makes them excellent candidates for studies of changes in ecological function and water quality assessment. Biological monitoring provides an effective method for determining if a watercourse has been impacted by a pollution source. Macroinvertebrates may live for several weeks to many years and are directly affected by habitat and water quality. As a result, macroinvertebrates can indicate pollution impacts from cumulative or multiple sources.

There has been interest in a Lady Bird Lake Index of Biotic Integrity (IBI) that would assess the relative health of Lady Bird Lake, both temporally and spatially. The goal of this study was to develop field assessment methods that could be used to document long-term temporal changes in the ecological health of Lady Bird Lake, and to evaluate potential spatial variation in the three targeted reaches.

The Surface Water team has in-house expertise in stream benthic macroinvertebrate collection, identification and analysis that could be transferred to reservoir/lake ecology without additional funding.

Research Objectives

- Are benthic macroinvertebrates communities in Lady Bird Lake significantly different spatially among the three targeted reaches?
  - What affect do the city of Austin's urban tributaries have on Lady Bird Lake (measured by the Above IH-35 site)?
  - How does the Basin, which is generally lacustrine, compare biologically to the two riverine upstream sites?
- How are release and non-release regimes biologically different?
  - Is there an important difference between communities collected during release and non-release periods?
  - Is one more representative of "equilibrium" or "best-attainable" condition?
- Will this method effectively document long term, temporal changes in benthic community health at these three locations?
  - Can this method be used in Lady Bird Lake index on an annual basis?
  - Detail what changes/modifications need to be made so that these methods can be used in a Lady Bird Lake Index.

Methods & Materials

Collection Methods

Benthic macroinvertebrates were collected at three transects along Lady Bird Lake. These transects were chosen to represent zones of the lake (Figure 1):

- MoPac – represents upstream un-impacted by urban streams portion
- IH-35 – represents downstream potentially impacted by urban streams
- Basin – represents a more lentic system analogous to a lake

At each transect a south littoral, north littoral, and sub-littoral samples were collected. Samples were processed in the field and were sub-sampled for target # of organisms to equal 200 organisms (± 20%). Samples were preserved in the field with 89% ethanol. Sampling occurred during two periods: release (September 2004, 2005, 2006) and non-release (March 2005, 2007). An additional sampling trip occurred in April 2007 to target specific habitats to determine if there were potentially rich habitats that were being excluded from the original study design. These habitats included creek deltas, lagoons and emergent aquatic macrophytes.

Littoral (less than one meter depth) samples were collected using 800µm kick net for all sampling, except during April 2007 when targeted habitat sampling occurred and 500µm nets were used. Nets used are Turtox bottom kick nets™ (457mm X 229mm), with bags that are 254mm deep. Samples were collected by two people for 1.5 man minutes each, for a total effort of 3 minutes. Total area sampled for kick net samples was 6m X 6m. The samples were composited into a plastic container (381mm X 483mm X 102mm) and carefully homogenized. The sample was then divided in half, with one half being placed into a Caton sub-sampler (318mm X 381mm X 51mm) (Caton, 1991). A Caton sampling tray consists of two parts; the lower portion is a solid plastic rectangle that has a metal tray that fits down into the plastic portion. The metal portion has a wire mesh bottom (500µm), which is divided into 30 equal 6cm^2

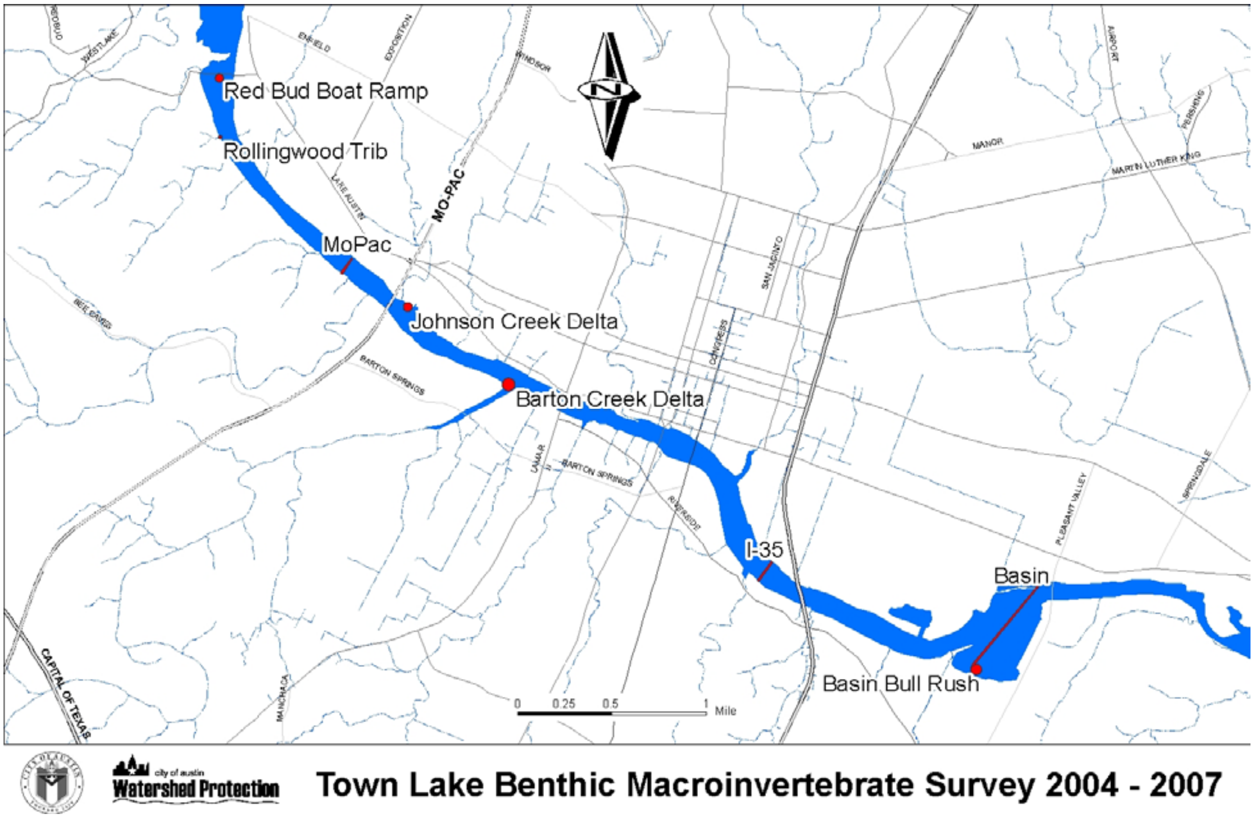

Figure 1. City of Austin Lady Bird Lake Benthic Macro-invertebrate survey sites (2004-2007).

squares. The sample is placed into the sub-sampler and water is added to the sample until the organisms and debris float. The sample is allowed to homogenize and then the metal pan is removed from the plastic portion leaving the water in the larger plastic portion, while the metal portion has an evenly distributed sample. A minimum of four grids are randomly selected and picked entirely. Additional grids are added to achieve the minimum target of 200 organisms (± 20%).

Sublittoral samples were collected using a Wildco® petite ponar dredge (152mm X 152mm sample area) from depths ranging 1-4 meters. A total of 6 replicate samples were taken, with three each representing a north and south portion of the transect. The 6 samples were compiled into and washed through an 800 µm net. It was then placed into the Caton sampling tray for sub-sampling if needed or picked in its entirety, depending on abundance.

Samples were processed at the City of Austin (CoA) Environmental Resource Management (ERM) lab. Benthic macroinvertebrates were identified to the lowest practical taxonomic level. Once identified specimens were placed in 70% ethanol for long-term storage. Rare and unusual taxa were sent off for third party verification, and voucher specimens were placed into the CoA reference collection.

Physio-chemical Parameters

Field parameters were collected at the surface (~0.2m depth) using a Hydrolab mini-sonde 4.0™ at all north and south littoral sites. Parameters included: dissolved oxygen (mg/L), pH (s.u.), specific conductivity (µS/cm), and temperature (°C).

Metric Analysis
Benthic macroinvertebrate metrics were calculated with Oracle® 8.1.7 using a PL/SQL procedure. Twenty-four metrics were calculated for the study (Appendix B).

Sampling Periods
Lady Bird Lake has two controlled hydrologic cycles per year and they are referred to as release and non-release periods. The release cycle (Mar-Oct) is when Lady Bird Lake takes on more riverine characteristics, and the volume of water passing through Lady Bird Lake increases, while the holding time of the water decreases. The release of water occurs along the chain of Highland Lakes and is controlled by the Lower Colorado River Authority (LCRA). The release period coincides with the rice growing season and the water is released for irrigation. The non-release cycle (Nov-Feb) is when Lady Bird Lake takes on more lacustrine characteristics and the volume of water passing through the reservoir decreases, while the holding time increases. Release versus non-release periods were compared on Lady Bird Lake to determine if one sampling time would be more effective than the other for sampling benthic macroinvertebrates.

Results

Release vs. Non-Release Sampling

Release period yielded 42% more total number of organisms than the non-release period. There is also an increase in the number of taxa collected during the release period (67) over the non-release (47) (Table 1). A total of 40 common taxa were collected for both periods. Seven taxa were collected during the non-release periods that were not accounted for in release period samples. However, during release period sampling, 27 new taxa were collected that were not represented during non-release samples. The seven taxa that could theoretically be un-represented during release period sampling have an average pollution tolerance index (PTI) value= 5.6, and only one sensitive organism is lost (*Nectopsyche* sp.) whose PTI = 3.

Table 1. Lady Bird Lake Release vs. Non-release periods using # Total Organisms and # Taxa collected from Sept 2004-Mar 2007.

Period	# Total Organisms*	# Taxa*
Release	6,923	67
Non-release	2,922	47

*only includes organisms collected from littoral samples during study.

Littoral vs. Sublittoral Sampling

North and south littoral samples were compared to sublittoral samples in order to determine if sublittoral sampling would be continued in future sampling of Lady Bird Lake using release period data only. Number of total taxa and total abundance were the first set of criteria used to make broad determinations for each type of habitat sampled. The littoral samples averaged between 2-3 times as many taxa as sublittoral samples. Even when average number of total organisms was low for a site (ex. Basin Littoral

North = 221) it was still represented by a high average # total taxa (26) (Table 2). When data was compiled to determine number of taxa for each zone sampled (i.e. littoral north, littoral south, and sublittoral) without regards to location (i.e. MoPac, IH-35, and Basin) the number of taxa present in the littoral areas was doubled compared to sublittoral taxa numbers (Table 3). Taxa collected from sublittoral samples were compared to taxa present at both north and south littoral samples. All the taxa represented in the sublittoral sites for 2004-2006 sampling were represented in the littoral samples.

Table 2. Lady Bird Lake Release period (2004-2006) littoral (north and south) versus sublittoral sampling by average number total taxa and average # total organisms collected for each location sampled.

Location	Avg # Total Taxa	Avg # Total Organisms
MoPac		
Littoral North	24	387
Littoral South	26	396
Sublittoral	10	185
IH-35		
Littoral North	16	379
Littoral South	21	264
Sublittoral	6	47
Basin		
Littoral North	26	221
Littoral South	25	605
Sublittoral	10	257

Several benthic macroinvertebrate metrics were used in conjunction with # taxa and total # of organisms to determine if sublittoral sampling could be eliminated from future studies on Lady Bird Lake. This qualitative score was tallied using a set of 12 metrics established by TCEQ for Rapid Bioassessment Protocols (TCEQ 2005). Qualitative scores are calculated using these metrics whose scores are then rated on a 4-1 scale, with 4 being high and 1 being a low score. This qualitative score, also known as the Aquatic Life Use score (ALU), is then assessed as: exceptional (>36), high (29-36), intermediate (22-28), and limited (<22). Littoral sites on Lady Bird Lake had an average ALU score of 22.4, while sublittoral sites averaged 18 ALU score (Table 3).

Table 3. Lady Bird Lake release period (2004-2006) total numbers of taxa, mean # taxa, mean # organisms and mean qualitative score for each zone benthic macroinvertebrates were collected.

Zone	Total # Taxa	µ Taxa	µ Org	µ QS
Littoral North	54	21.5	329	22
Littoral South	59	23.9	421.6	22.8
Sublittoral	25	8.7	163.7	18

North vs. South Littoral Sampling

Taxa were compared between north and south littoral to determine if sampling both sides of the lake were needed to adequately represent the littoral areas of Lady Bird Lake. Taxa were compared from release period data only, and there were a total of 44 taxa common between the north and south littoral samples. The north littoral samples had 8 taxa not represented in the south littoral samples (total taxa=54); while south littoral samples had 15 taxa not represented in the north littoral samples (total=59). Means calculated for total taxa and total organisms for north and south littoral zones showed a slight increase in both calculations in the south littoral samples (Table 3). When looking at the raw data for sample dates south littoral sites generally scored higher in both categories. Qualitative scores, both raw data (not presented) and means were also typically higher, although not significantly higher, for south littoral sites than north littoral sites (Table 3).

When examining taxa that were present in only north or south littoral, average PTI values are not different (6 and 6.6 respectively) between localities. However, when looking at individual taxon PTI values for north littoral samples, only two taxa have PTI values ≤ 5 (*Camelobaetidius* and *Tricorixia*) (Appendix C). The addition of the genus *Camelobaetidius* sp. is questionable due to the type of habitat typically associated with this genus. *Camelobaetidius* spp. inhabit streams with cobble to boulder type substrates and are often associated with waterfalls (travertine) (Traver and Edmunds 1968). This type of habitat is limited at best in Lady Bird Lake, and the addition of this taxon into Lady Bird Lake is due to flows that carried it downstream from a creek containing suitable habitat. If this taxon was eliminated from the north littoral taxa list the average PTI value would then be 6.3, closer to that of the 15 taxa of the south littoral sampling. Of the 8 taxa collected from the north littoral sampling, six had a PTI value of either 6 or 7.

The 15 taxa collected from the south littoral sampling provided several with a PTI value ≤ 5 (*Elmia comalensis* {5}, *Gammarus* {3}, *Oxytheria* {2} and *Triaenodes* {3}). PTI values for these 15 taxa ranged from 10-2, with one genus, *Pantala*, not having a PTI value. *Pantala* is an odonate and as an order they typically have higher PTI values. Other odonates collected from this sampling had PTI values >5.

When comparing these localities overall, the qualitative scores are close for this sampling period: north littoral = 22, south littoral = 22.8 (Table 3). Since a large majority of the taxa collected are in common with both localities, calculating mean PTI values would not lend much resolution to distinguishing differences between north and south littoral samples. Examining the taxa not in common gives a clearer understanding of the differences between these two sides of Lady Bird Lake, and can potentially offer support that there is a higher amount of habitat limitation or degradation on the north side of the lake. Even though the south had three taxa with a PTI value of 10 (*Belostoma*, Collembola and *Laccophilus*), the range of PTI values lends support to the assumption that habitat is varied and can support a wide range of taxa.

Targeted Sampling

Targeted sampling in April 2007 focused on habitats not sampled during the original pilot study on Lady Bird Lake. Sites sampled were (Figure 1):

- Basin South Shore Bull Rush
- Johnson Creek Delta
- Barton Creek Delta
- Red Bud Boat Ramp
- Lady Bird Lake South Shore @ Rollingwood Tributary

These sites were targeted to establish if sampling during the original study was providing adequate representation of taxa diversity in Lady Bird Lake, or if large numbers of taxa were missed during the pilot study due to patchiness in available habitat.

Methods for this survey followed protocols listed above, except for how individual organisms were sampled. Since this targeted sampling was designed to assess missing taxa and to ascertain total taxa richness, one of every taxa present were collected and previously non-collected taxa were targeted. This portion of the study was not done qualitatively; therefore comparison between this sampling and previous sampling can only be done on a limited basis.

Comparing taxa collected during the targeted habitat sampling (2007) to the 2004-2007 benthic macroinvertebrate survey the following new specimens were added to the previous taxa collected:

- Order = 1
- Families = 2
- Genera = 8
- Species = 4

A majority of the organisms collected from this habitat driven sampling were odonates (dragonflies), and they consisted of an additional five genera and three species. An unexpected finding was the collection of the native mussel, *Pyganodon grandis* “Giant Floater”, at the Red Bud Boat Ramp. These mussels are often found in a variety of substrates, but are most commonly found in soft muddy bottoms, and are more commonly found in no-flow conditions (Howells *et al.* 1996). In Lady Bird Lake this specimen was collected in a lagoon area where the substrate consisted of cobble to large boulders, with a layer of soft sediment and algae.

The number of taxa present in each of the targeted habitats was fairly close to the averaged numbers of taxa for individual site transects (Table 4, Table2 respectively). Qualitative scores shown here in Table 4 are higher than those shown in Table 3. The qualitative scores below place these habitats in the intermediate-high ALU category. However, ALU scores calculated here are not done in conjunction with qualitative sampling methods so they should only be used as a guideline for comparison.

Table 4. Lady Bird Lake Targeted Habitat Benthic Macroinvertebrate Survey (2007) # of taxa present at each site with qualitative scores.

Location	# Taxa	Qualitative Score*
Bull Rush	20	24
Johnson Creek	27	26
Barton Creek	30	28
Red Bud	30	27
Rollingwood	27	27

*qualitative score metrics were calculated using data collected during this targeted habitat survey. Since this data was not collected using qualitative measures it is only being used as a guideline and for comparison values.

Benthic Macroinvertebrates

Benthic macroinvertebrates collected during the initial study from 2004-2007 are described in more detail in Appendix D.

Conclusions

A total of 84 benthic macro-invertebrate taxa (12,300+ organisms) were collected from Lady Bird Lake (2004-2007), representing 9 orders of insect taxa and 10 orders of non-insect taxa (not including Phylum Annelida which was identified to subclass). Seventy-three percent of the taxa collected were insects, but non-insect taxa constituted 71% of the total abundance of organisms collected during the study.

Since Lady Bird Lake is considered a flow through reservoir operated by the LCRA there are two distinct periods of the lake classified as release (September) and non-release (March). Comparison of these periods showed that the release period sampling had greater number of individuals collected as well as a higher number of taxa present. This is a period where the reservoir is more riverine and therefore lends itself to providing habitat for benthic macro-invertebrates that require higher oxygen levels or flow, which increase with the release of water from the Longhorn Dam. Release and non-release periods had several important biological differences; however, which is the best attainable condition is not easily answered for these two periods. If Lady Bird Lake macroinvertebrate studies need to be compared to other City of Austin monitoring programs, then sampling should be done at a time when a higher number of taxa and individuals are present. Therefore the best attainable condition would be release period sampling. Differences between taxa are negligible for these two periods. However, sampling earlier in the release period (April or May), as well as the critical period could provide useful information on taxa that could have emerged earlier in the year that could be univoltine (one generation per year) or diapaused (period of suspended development due to unfavorable conditions).

Along with establishing if one of the flow regimes was more desirable, sampling focused on three transects to represent lacustrine (Basin), urban impacts (IH-35), and best attainable (MoPac) sites. Comparison of these transects shows (from upstream to downstream) that the MoPac site has less impacted habitat and higher taxa present and abundance. Also, some less tolerant species are present there as well. IH-35 shows degradation due to impacts of the urban creeks that are located upstream of this site. However, for the littoral samples of IH-35 average number of total taxa is comparable to that of MoPac and Basin sites. Even average number of total organisms was similar for this location in respect to the other two sites. Sublittoral sampling at IH-35 showed a drop in taxa and a significant difference in average number of total organisms. These changes could be attributed to the influence of urban creeks above this site. At the Basin taxa numbers and abundance increase which could be a sign of recovery at this location. Also, at the Basin taxa associated with pond-like habitats were more often encountered than at the other sites.

At each transect three samples were taken: north littoral, sublittoral, and south littoral. Sublittoral samples yielded very low abundances and little new taxa, and a majority of taxa collected from these samples were Chironomidae (non-biting midges). Sublittoral samples were deemed unproductive due to the vast amount of sediment and time needed to process these samples with very little return. Littoral samples were compared to determine if either the north or south shores were more diverse, or if they were relatively the same could one be eliminated from the sampling protocol. South littoral samples yielded higher total taxa, with an additional 15 taxa not collected in north littoral samples. These 15 taxa had a wide range of PTI values in comparison to the north littoral taxa (8) not collected in the south littoral samples.

In conclusion Lady Bird Lake has a diverse benthic macro-invertebrate community. Of the 10 orders of aquatic/semi-aquatic insects listed in *An Introduction to the Aquatic Insects of North America* 4th (Merritt *et al.* 2008) [with exclusion of semi-aquatic Orthoptera and Hymenoptera], the Lady Bird Lake survey had 9 orders present. Of the three orders considered sensitive (Ephemeroptera, Plecoptera, and Trichoptera), two were collected from Lady Bird Lake (Ephemeroptera and Trichoptera). Mayflies (Ephemeroptera) were represented by 5 families and 8 genera, while caddisflies (Trichoptera) were represented by 4 families and 9 genera. Odonates, dragonflies and damselflies, by far dominated the taxa collected. They were represented by 6 families and 20 genera.

This sampling method provided a much needed broad scale view of the benthic community in Lady Bird Lake. Sampling could be conducted on a yearly or bi-annual basis to assess long-term trends in the benthic community composition in Lady Bird Lake. Additional information could be obtained from depth profiles, which could be used to help understand the dynamics of urban creek influences at IH-35 sites. Depth profiles should also be conducted at the other two sites for comparison, especially if profiles are similar for all three locations, then further investigation is warranted for IH-35 to determine if there are other factors contributing to lower total taxa numbers. Even though sublittoral samples will not be conducted in the future, IH-35 sublittoral samples were much lower than the other two sites. Therefore, depth profiles should be conducted here to monitor any potential on-going problems at this location. Changes to this sampling plan could be the inclusion of all or some of the additional sites sampled in April 2007, as well as the removal of sublittoral and north littoral samples.

Recommendations

- Lady Bird Lake sampling should occur only during the release period
- Lady Bird Lake sampling should exclude sublittoral sampling
- Lady Bird Lake sampling should incorporate these habitats
  - South littoral if both shores cannot be sampled
  - Specific targeted areas
    - Reference – MoPac South Littoral and Red Bud Boat Ramp
    - Urban Impacts – IH-35 South Littoral and Johnson or Barton Creek Deltas
    - Lacustrine – Basin
- Water quality should be obtained from Lady Bird Lake Water Quality project and used to detect trends over time.
  - Depth profiles at each transect should be used to determine if there are significant differences between MoPac, IH-35 and Basin.
- Unionidae collected from Lady Bird Lake, part of Freshwater Mussel Survey should be included in this report as well.
- Chironomidae larvae should be identified to genus
  - Additional survey of Chironomidae pupal exuviae should be done in conjunction with regular benthic macroinvertebrate surveys, but on a higher sampling frequency.

INSECT TAXA

Order Collembola

Order Ephemeroptera

Family Baetidae

Callibaetis

Camelobaetidius

Fallceon quilleri

Family Caenidae

Caenis

Family Ephemeridae

Hexagenia

Family Heptageniidae

Stenacron

Stenonema

Family Leptohyphidae

Tricorythodes

Order Odonata

Family Aeshnidae

Anax

Nasiaeschna pentacantha

Family Coenagrionidae

Argia

Enallagma

Ischnura

Family Cordullidae

Epitheca (Epicordulia) princes

Macromia

Family Gomphidae

Aphylla

Family Lestidae

Lestes

Family Libellulidae

Brachymesia furcata

Brechmorhoga mendax

Dythemis fugax

***Dythemis* sp.**

Erythemis

Libellula

Pachydiplax longipennis

Pantala

Perithemis tenera

Plathemis lydia

Tramea

Order Hemiptera

Family Belostomatidae

Belostoma

Family Corixidae

Trichocorixa

Family Gerridae

Rheumatobates

Trepobates

Family Nepidae

Ranatra

Family Veliidae

Macrovelia

Order Megaloptera

Family Sialidae

Sialis

Order Trichoptera

Family Hydropsychidae

Cheumatopsyche

Nectopsyche

Family Hydroptilidae

Hydroptila

Orthotrichia

Oxyethira

Family Leptoceridae

Oecetis

Triaenodes

Family Polycentropoidae

Cernotina

Polycentropus

Order Coleoptera

Family Dytiscidae

Agabus

Berosus

Laccophilus

Family Elmidae

Dubiraphia

Stenelmis

Family Haliplidae

Peltodytes

Family Scirtidae

Scirtes

Order Diptera

Family Ceratopognidae

Bezzia (Palpomyia)

Culicoides

Dasyhelea

Probezzia
Serromyia
Family Chironomidae
Chironominae
Orthocladiinae
Tanypodinae
Tanytarsini
Family Ephydridae
Family Stratiomyidae
Caloparyphus

NON-INSECT TAXA

Phylum Arthropoda
Order Amphipoda
Family Gammaridae
Gammarus
Family Hyalellidae
Hyalella
Order Anomopoda
Family Daphniidae
Daphnia
Order Copepoda
Order Decapoda
Family Cambaridae
Procambarus
Family Palaemonidae
Palaemonetes
Order Hydracarina
Class Ostracoda

Phylum Mollusca
Order Basommatophora
Family Ancylidae
Ferrissia
Family Lymnaeidae
Fossaria
Family Physidae
Physa (Physella)
Family Pisidiidae
Sphaerium
Family Planorbidae
Gyraulus
Helisoma anceps
Order Neotaeniglossa
Family Hydrobiidae
Cincinnatia cincinnatiensis
Family Pleuroceridae
Elimia comalensis

Family Thiaridae

Melanoides tuberculatus

Order Palaeoheterodonta

Family Unionidae

Anodonta grandis

Order Veneroida

Family Corbiculidae

Corbicula fluminea

Phylum Annelida

Subclass Hirudinea

Subclass Oligochaeta

Phylum Platyhelminthes

Order Tricladida

Family Planariidae

Dugesia tigrina

* This list includes all taxa collected during 2004-2007 Lady Bird Lake Benthic Macroinvertebrate Study.
** Items annotated in **RED** were collected during April 2007 during a habitat / benthic macroinvertebrate survey to assess if taxa were missed during Lady Bird Lake pilot study

Appendix B

Metrics

# Organisms	Total number of benthic organisms in sample
# Taxon*	# of unique benthic taxa
% Dominance (1 taxon)*	# of organisms of most numerous singe taxon as % of total # of organisms
% Dominance (3 taxa)	# of organisms of top 3 most numerous taxa as % of total # of organisms
% Dominant Guild	# of organisms of most numerous feeding group as % total # of organisms
HBI*	Average PTI value of all organisms; taxa with no PTI value are excluded
# Diptera Taxa	# of unique taxa representing the Order Diptera
# Ephemeroptera Taxa	# of unique taxa representing the Order Ephemeroptera
% EPT	# or organisms from Ephemeroptera, Plecoptera & Trichoptera orders as % total org
# EPT taxa*	# of unique taxa from Orders: Ephemeroptera, Plecoptera, Trichoptera
EPT/EPT+Chironomidae	# of EPT organisms as % of the sum of # of organisms in EPT and family Chironomidae
% Chironomidae*	# of organisms in family Chironomidae as % of total organisms
% Elmidae*	# of organisms in family Elmidae as % of total organisms
# Non-Insect Taxa*	# of unique taxa not in Class Insecta
% Collector-Gatherer*	# of organisms in CG functional feeding group as % of total organisms
% Predator*	# of organisms in the Predator functional feeding group as % of total organisms
% Filterer	# of organisms in the Filterer functional feeding group as % of total organisms
% Grazers	# of organisms in the Grazer functional feeding group as % of total organisms
% Trichoptera as Hydropsychidae*	# of organisms in Hdropsychidae as % of total organisms in Order Trichoptera
Intolerant : Tolerant*	Ratio of # of organisms with PTI value ≥ 6 to # of organisms with PTI < 6
# Intolerant Taxa	# of unique taxa with a PTI value ≤ 4
% Tolerant	# of organisms with a PTI value ≥ 8.5 as % of total # of organisms
Quantitative ALU	TCEQ quantitative aquatic life use score
Qualitative ALU	TCEQ qualitative aquatic life use score

(*) are metrics used to calculate Aquatic Life Use scores.

Appendix C

North

Camelobaetidius	4	Avg = 6
Chematopsyche	6	
Culicoides	7	
Probezzia	6	
Ranatra	7	
Serromyia	6	
Stenelmis	7	
Tricorixia	5	

South

Belastoma	10	Avg = 6.6
Brechmorhoga mendax	6	
Caloparyphus	7	
Cernotina	6	
Collembola	10	
Elimia comalensis	5	
Ephydridae	6	
Epitheca princes	5.6	
Gammarus	3	
Laccophilus	10	
Lestes	9	
Libellua	8	
Oxytheria	2	
Pantala		
Triaenodes	3	

Appendix D

Benthic Macroinvertebrates

Insect Taxa

Several aquatic insect orders are considered to be indicators of good water quality due to their inability to inhabit polluted waters with low dissolved oxygen concentrations. Particularly intolerant benthic macroinvertebrate orders include Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), commonly referred to as the EPT taxa. Sampling in Lady Bird Lake (2004-2007) routinely collected specimens of Ephemeropterans and Trichopterans. Substrate in Lady Bird Lake may not have been suited for Plecopterans due to their affinity for cold, moderate-high flow, rocky habitats. These orders are all hydropneustic breathers, and must acquire oxygen for respiration via the water system, so water systems where these organisms are found must contain a fair amount of dissolved oxygen. Even though these three orders of aquatic insects can give some insight into water conditions/pollution it is still valuable to understand the entire benthic macroinvertebrate community structure. A total of 8 orders, 29 families, and 52 genera were collected from Lady Bird Lake. An additional survey done in April 2007 targeted habitats not sampled during the pilot study, and additional taxa will be discussed later as supplemental findings.

The Order Collembola “springtails”, were recorded only from the Basin (Sept 2005). As an order the springtails inhabit a variety of habitats. Aquatic springtails inhabit interstitial spaces in littoral habitats. Due to their small size and their hydrophobic integument they are generally found “springing” across the surface of water. They are generally detritus feeders, but some feed upon diatoms, unicellular algae, and surface trapped plankton (Christiansen and Snider 1996).

The Order Ephemeroptera (mayflies) was recorded from each area sampled:

- Mopac 5 families* 8 genera
- IH-35 4 families 5 genera
- Basin 4 families 6 genera

The families collected were Baetidae, Caenidae, Ephemeridae, Heptageniidae, and Leptohyphidae, all were collected at each site with the exception of Ephemeridae*. Mayfly nymphs are usually classified into the functional feeding groups of collectors and scrapers and feed on a variety of detritus and algae, and some macrophyte and animal material (Edmunds and Waltz 1996).

Baetid mayfly nymphs generally inhabit lotic erosional and depositional areas and are widespread; they are good swimmers and clingers and are typically classified into the following feeding groups: collectors, gathers, and scrapers (Edmunds and Waltz 1996). These mayflies are easily distinguished from other mayflies by having one tarsal claw, antennae that are twice the width of the head, and 2-3 caudal (tail) filaments.

Caenid mayfly nymphs inhabit lotic depositional, lentic and littoral sediments; they are sprawlers and clingers and are typically classified into the following feeding groups: collectors, gathers, and scrapers (Edmunds and Waltz 1996). They are easily distinguished from other mayflies by their operculate (square) gill coverings, which allow them to inhabit finer sediments.

Ephemerid mayfly nymphs inhabit lentic and lotic depositional sediment (sand-silt); they are widespread burrowers and are classified into the following feeding groups: collector – gatherers (Edmunds and Waltz 1996). These nymphs are easily distinguished from all other mayfly nymphs due to the presence of mandibular tusks. There is one other family of mayflies with mandibular tusks as nymphs, but the separation of these two families is due to the upward curving tusks (Ephemeridae) or downward curving (Polymitarcyidae).

Heptageniid mayfly nymphs inhabit lotic and lentic erosional areas; they are dorso-ventrally flattened and are considered clingers and are classified into the following feeding groups: scrapers, collectors, and gathers (Edmunds and Waltz 1996). This dorso-ventral flattening allows these nymphs to cling to the surface or bottom of rocks to avoid being swept downstream by the flow of water.

Leptohyphid mayfly nymphs are typically found in lotic-depositional and lentic-littoral habitats. They are considered to be clingers and sprawlers and are classified as collector-gathers. They can be confused with Caenid nymphs due to the presence of operculate gill coverings, but are distinguished in having triangular gill coverings. As with the Caenid nymphs these operculate gill coverings allow them inhabit fine sediments (Edmunds and Waltz 1996).

Order Odonata (dragonflies & damselflies) were recorded from each area sampled:

- Mopac 4 families 5 genera
- IH-35 4 families 11 genera
- Basin 6 families* 10 genera

The seven families collected were Aeshnidae*, Coenagrionidae, Cordullidae, Gomphidae, Lestidae*, Libellulidae, and Macromiinae**. Families (*) and sub-families (**) denoted with asterisks were only collected from the Basin sampling. Odonate nymphs generally inhabit a great diversity of aquatic habitats, but prefer lowland streams and ponds. The nymphs are an important part of the aquatic food web because they are voracious predators. They have a hinged labium (lower lip) that is thrust forward and out to catch prey. They feed on a variety of aquatic invertebrates and fish. Odonate nymphs conceal themselves either by burrowing into the substrate, or sprawling among fine sediment, detritus or climbing vascular plants (Westfall and Tennessen 1996). The distinction between dragonfly and damselfly nymphs is fairly easy. Dragonfly nymphs have no external gills, while damselfly nymphs have 3 caudal gills often referred to as "tails or filaments". Dragonfly nymphs pull water into their abdomen and expel it as a form of "jet propulsion" to move forward, but its major function is for respiration.

Family Aeshnidae (dragonflies) are commonly referred to as "darners". They are primarily inhabit lentic-littoral areas, and are especially fond of vascular hydrophytes. Nymphs are considered climbers and are engulfing predators (Westfall and Tennessen 1996). They are some of the larger nymphs and are commonly referred to as "cigar-shaped".

Family Coenagrionidae (damselflies) inhabit a wide range of lentic and lotic habitats. They are climbers and feed by predation (Westfall and Tennessen 1996). Morphologically this family contains a few genera that are distinguished by patterns present on the eyes.

Family Cordullidae (dragonflies) nymphs primarily inhabit lotic-depostional areas in small streams and large rivers. They are sprawlers and climbers and are also predators (Westfall and Tennessen 1996). This family is easily mistaken for Libellulidae in the nymphal stage. Some taxonomists place this family as a sub-family under Libellulidae.

Family Gomphidae (dragonflies) generally inhabit lotic depositional and lentic littoral zones. They are burrowers and are predaceous (Westfall and Tennessen 1996). The only genus collected from this family was *Aphylla* sp. which easily identified in the field. The last abdominal segment of this genus is elongated and is more than half as long as all other abdominal segments combined.

Family Lestidae (damselflies) nymphs are generally found in lotic-depositional and lentic-littoral habitats. They are climbers and are classified as predators (Westfall and Tennessen 1996). These damselflies are easily separated from other damselfly families by their labium (lower-lip), which is on an elongated-thin stalk. They are also generally larger than other damselfly nymphs.

Family Libellulidae (dragonflies) are lentic-vascular hydrophytes inhabitants, and are predaceous sprawlers (Westfall and Tennessen 1996). As adults these dragonflies are easily sorted to family from Cordullidae adults due to wing veination, but are difficult to distinguish apart in the nymphal stage.

Sub-family Macromiinae (dragonflies) are predaceous sprawlers that inhabit lentic-littoral and lotic-depositional habitats. They are often found in sand and silt substrates. Identification of they nymphs from other dragonfly nymphs can be done by body shape and other morphology in the field. The abdomen is strongly depressed, and circular in shape. They have a prominent horn between the base of the antennae, and all the legs are extremely long with the hind leg femur reaching well beyond or to the margin of the abdomen (Westfall and Tennessen 1996). Several taxonomists place this as a sub-family of either the Libellulidae (Needham *et al.* 2000) or Cordullidae (Abbott 2005, Westfall and Tennessen 1996) families.

The Order Hemiptera (true bugs) was collected from each area sampled:

- Mopac 2 families 3 genera
- IH-35 2 families 2 genera
- Basin 3 families 4 genera

A total of 4 different families were collected: Belostamatidae, Corixidae, Gerridae, and Nepidae, with only the Gerrids being collected at all three locations. In North America 15 of the 17 major aquatic families of Hemipterans are represented. Of those 17, 6 are totally aquatic with the adults leaving only to migrate. Three of the families live upon the surface of the water, while the others live along the water margins or within the water column. Aquatic Hemipterans come in a variety of forms and occupy a wide variety of habitats and niches. The majority are predators due to their sucking-piercing mouthparts. Other adaptations include siphons located at the tip of the abdomen for breathing atmospheric oxygen (Pohlemus 1996).

Family Belostamatidae are commonly referred to as "giant water bugs". They are generally found in lotic-depositional and lentic-littoral areas, and are often collected among aquatic macrophytes and detritus. Belostomatids are piercing predators that are adapted for climbing as well as swimming (Polhemus 1996). These large, ovate, flattened insects are powerful predators due to their raptorial forelegs. They breathe atmospheric oxygen via two siphons located at the terminal end of the abdomen. Belostomatids are known for attacking prey many times their size, which can include fish, frogs and small birds. Generally they feed upon small vertebrates such as tadpoles, and aquatic insects. The genus *Belostoma*, which was collected from Lady Bird Lake, is unique in that the eggs of this genus are laid by the female on the back of the male who carry them until they hatch (Polhemus *et al.* 1988).

Family Corixidae are commonly called "water boatmen". Boatmen are typically found in lentic or lotic depositional areas. They are good swimmers and are usually classified as piercers, although some are herbivorous (Polhemus 1996). Their common name is derived from the way they "swim" through the water using their rear legs as oars. Often confused with Notonectidae "backswimmers" the easiest way to tell these two families apart is by watching them swim. As the name implies "backswimmers" swim on their backs. The dorsal portion of the insect is downward in the water, while the boatmen swim dorsal side up (Polhemus *et al.* 1988).

The Family Gerridae is referred to commonly as "water striders". They are commonly located in lentic-limnetic, or lotic water surfaces. They "skate" across the surface of the water in search of prey (Polhemus 1996). This family is the second largest family of the aquatic and semi-aquatic Hemipterans. They are considered to be some of the most conspicuous of the aquatic Hemipterans due to their prominence on the waters surface (Smith 1988).

Family Nepidae or "water scorpions" as they are commonly called are usually collected from lotic-depositional or lentic-littoral zones in aquatic macrophytes or detritus. They are poor swimmers, but do climb on or hang onto aquatic macrophytes in search of prey. They are piercing predators (Polhemus 1996). Their common name comes from their elongated form, raptorial front legs used to acquire prey, and long siphon at the end of their abdomen. Water scorpions are extremely proficient predators due to their cryptic coloration and their ability to lie in wait amongst submerged vegetation, debris and weeds. These insects are very sluggish and often are heavily parasitized by water mites, and often when collected they will feign death. Only two genera are found in Texas, *Ranatra* and *Curicta* (Polhemus 1988).

Order Megaloptera (dobsonflies) was collected from each location. Only one family (Sialiade) and genus (*Sialis* sp.) was collected from Lady Bird Lake. Aquatic Megalopteran larvae are large predators that inhabit both lentic and lotic waters. Sialid larvae prefer water systems that have soft substrate where detritus is abundant. These larvae are burrowers and feed on a wide range of aquatic fauna (Evans and Neunzig 1996).

Order Trichoptera (caddisflies) were collected from each area sampled:

- MoPac 4 families 6 genera
- IH-35 4 families 5 genera
- Basin 4 families 8 genera

The same four families were collected from each site: Hydropsychidae, Hydroptilidae, Leptoceridae, and Polycentropoidae, while a total of 9 different genera were collected from Lady Bird Lake. Only two genera were collected from each sample site: *Oecetis* (Leptoceridae) and *Polycentropus* (Polycentropoidae). Caddisfly larvae occur in most types of freshwater systems, and all the North Ameircan families are represented in cool, lotic waters. They typically feed on algae, diatoms, decaying vascular plant tissue, and some are predaceous. Caddisflies are known for their remarkable cases, nets and retreats they construct out of various materials. Retreats and cases vary in design and function and can sometimes be diagnostic to the genus level (Wiggins 1996).

The Family Hydropsychidae is known for their larvae which do not make cases, instead they make elegant silken nets that are used to filter food out of the water column. Studies have looked at these silken nets and have determined that different genera weave nets of different mesh sizes to collect food particles of particular size ranges (Wiggins 2000).

Family Hydroptilidae are commonly referred to as "microcaddisflies". The cases they make are often called purse or barrel cases. Microcaddisflies feed by piercing aquatic macrophytes, scraping algae, or are collector-gatherers (Wiggins 1996). The cases constructed by these larvae are done in such a way that the case is easily expanded upon to accommodate the swelling abdomens of the larvae. Larvae in this family generally range from 2-3 mm in length, but can reach 6 mm (Wiggins 2000). This family had the most representation with 3 genera collected, *Hydroptila*, *Orthotrichia*, and *Oxytheria*.

Family Leptoceridae are case builders, and do so with a variety of materials. They inhabit all types of lotic and lentic habitats. They are considered to be collector-gatherers, shredders-herbivores, and predators (Wiggins 1996). One morphological characteristic that makes it easy to distinguish these caddisfly larvae from others is their rather long hind legs. *Triaenodes* is a Leptocerid caddisfly that was collected from Lady Bird Lake, and this genus is easily identified by its case that is made from plant pieces arranged in a spiral. This genus is also very easily identified without the case by the two parallel, dark lines on the dorsal portion of the head. *Nectopsyche* was also collected from Lady Bird Lake and it is also easily identified by its case. The case included long twigs or plant material extending beyond one end of the case. There is also another large piece of plant material attached to the case that acts as a ballast (Wiggins 2000).

Polycentropids are net-spinning retreat caddiflies. They are found in lotic-erosional areas, and are considered collector-filterers but some are predaceous (Wiggins 1996). This family was represented only by *Polycentropus*, which as larvae build flimsy trumpet-like nets that are suited to gentle currents (Wiggins 2000).

Coleopterans (beetles) were collected from each site:

- MoPac 3 families 5 genera
- IH-35 3 families 2 genera
- Basin 4 families 5 genera

Two(*) of the four families collected were represented at each location: Dytiscidae*, Elmidae, Haliplidae*, and Scirtidae. Only one genus was found at each location, *Peltodytes* (Haliplidae). Beetles are important in some aquatic food webs, but few species reach the biomass levels attained by mayflies, caddisflies, or true flies, which are major components of the aquatic food web. They are generally not the most dominate organisms in lotic water systems. They occupy a broad variety of habitats and a wide variety of trophic levels. Several different forms of respiration are found within the aquatic coleopterans (White and Brigham 1996).

Dytiscid beetles "predaceous diving beetles" are some of the best adapted insects for aquatic life and the most diverse of the aquatic beetles. These beetles are predaceous, but some incorporate scavenging as a mode of acquiring food. They are known to leave the water and fly, but do so by crawling up onto an object out of the water. Upon return adults just splash back into the water, this is due to the modification of the hind legs for swimming and not for walking (White and Brighman 1996).

Elmid "riffle beetles" generally inhabit swifter portions of streams and rivers. Two genera were collected from Lady Bird Lake, *Stenelmis* and *Dubiraphia*, which are two of the three wide spread genera occurring in this family. They typically inhabit lotic and lentic erosional areas, they are clingers, and generally feed by collecting, gathering, and scraping (White and Brighman 1996).

"Crawling Water Beetles" are in the Family Haliplidae. This was the only family represented by the same genus, *Peltodytes*, at each location. They are easily identified in the field by the presence of two black spots located right above their wings. This genus are good swimmers and feed by piercing and shredding aquatic macrophytes (White and Brighman 1996).

Scirtidae or "marsh beetles" are poorly known in both their taxonomy and ecology. This family is synonymous with the family Helodidae. The larvae live in lentic areas that contain aquatic macrophytes that are emergent. Adults are terrestrial with a few that could be semi-aquatic. The larvae are climbers and sprawlers and feed as scrapers, collector-gatherers, shredders-herbivores, and piercer-herbivores. Larvae are easily identified by long, many segmented antennae (White and Brighman 1996).

Order Diptera (true flies) were collected from each site:

- MoPac 2 families 4 genera
- IH-35 2 families 1 genera
- Basin 4 families 3 genera

Only two families were collected from each location, Ceratopognidae and Chironomidae. Other families collected included: Ephydridae and Stratiomyidae. Dipterans have successfully colonized every aquatic habitat, except the ocean. Larvae that live in lotic habitats range from slow, silty rivers to clean, torrential streams. Lentic habitats also vary from lakes to tree holes. Their trophic diversity, not only makes dipterans important primary consumers but they serve as a food source for other invertebrates, fish, amphibians, reptiles, birds, and mammals. Chironomidae, are often the most abundant organisms in both number and biomass, can be significant in ecosystem functioning. Dipterans also have important roles in water quality monitoring, biomonitoring, conservation biology, as well as other areas of aquatic ecology (Courtney *et al.* 1996).

Ceratopogonidae or "biting midges, or no-see-ums" are small worm-like dipterans. They can be found in a variety of habitats including tree holes, small temporary ponds and pools. Ceratopogonids are sprawlers, burrowers or planktonic and are generally feed by predation but can also be collector-gatherers (Courtney *et al.* 1996). Five genera were collected from Lady Bird Lake, but only *Beezia* was collected from all three sites. They are easily distinguished from Chironomidae larvae due to their long thin bodies, and snake like movements (Voshell 2002).

Chironomidae "midges" are an ecologically import group of aquatic macroinvertebrates that occur often in high densities and diversity. They feed on a wide variety of substances, and therefore fit into several functional feeding groups. Midges occur in most aquatic ecosystems, moist soils, tree holes, pitcher plants and dung. Their range of living conditions is more extensive than any other aquatic group. Along with this ability of extreme habitat diversity, they can also inhabit a wide range of temperatures, pH, salinity, oxygen concentrations, current velocities, depths, productivity, altitude, and latitude (Coffman and Ferrington 1996). For the purpose of this study Chironomid larvae were identified to subfamily and tribe if possible. At all locations 3 subfamilies were collected: Chironominae, Orthocladinae, and Tanypodinae. In some instances further identification of some Chironominae to the tribe Tanytarsini occurred.

Ephydridae "shore and brine flies" can be collected from lentic-littoral margins and around aquatic macrophytes, where they can be found burrowing into sediment or sprawling. They feed primarily as collector-gatherers but also as shredders-herbivores (miners), scrapers, and predators (Courtney *et al.* 1996). These larvae are known to inhabit some of the harshest habitats of any aquatic insects, and have been collected from the Great Salt Lake, the Rancho la Brea tar pits, pools of crude petroleum in oil fields, alkaline springs in the West, and pools of geothermal water from geysers at Yellowstone National Park (Voshell 2002).

Family Stratomyidae are commonly referred to as "solider flies". They are usually in lentic-littoral habitats where they feed as collector-gatherers. Larvae are considered sprawlers and swimmers (Courtney *et al.* 1996). They are identifiable by their "leathery" exoskeleton and spiracles at the end of their abdomen. The spiracles are used to obtain atmospheric oxygen (Voshell 2002).

Non-Insect Taxa

While their counterparts have been widely studied in relation to the ecology of running waters, non-insect benthic macroinvertebrates are generally poorly understood. These benthic macroinvertebrates include sponges, tubellarians, oligochaetes, leeches, crustaceans, mites, and mollusks (Hynes 1970). Some non-native species are of particular importance, but not all non-natives are seen as bad. Their positive value out-weighs their negative aspects (i.e. non-native mussels). Four phyla, 9 orders, 13 families, and 13 genera were collected from all sites on Lady Bird Lake. The MoPac site reported an additional 2 families and 2 genera. A complete list of taxa will be appended at the end of this report.

Non- insect arthropods collected from Lady Bird Lake are in the sub-phylum Crustacea, and are often referred to as crustaceans. They are the most diverse of any groups of arthropods and live in a variety of habitats. While many are adapted to life in water (both fresh and salt water), there are a few which are terrestrial. Aquatic crustaceans feed primarily on phytoplankton, but some feed upon detritus and decaying matter. A few of the more well known crustaceans are crawfish and shrimp, which have become a part of the commercial fishing industry (Covich and Thorp 2001).

Mollusks collected from Lady Bird Lake were the same at each site, except for MoPac which had an additional two families and two genera. This phylum is split into two classes: Gastropoda and Bivalvia. The gastropods are the most diverse class within Mollusca. The organisms most widely known from this class are snails. Snails feed on a variety of substances including: detritus, periphyton, and algae. They can be found on land, water margins, as well as being totally aquatic. Aquatic snails often control the amount and composition of periphyton in both lentic and lotic water systems. They are an important part of the aquatic ecosystem, and become food for upper level vertebrates such as fish and wading birds. Snails are easily identified by their shells which are secreted by their fleshy mantle (body). Their shell is univalve a distinction made between them and the other group of mollusks the bivalves. Along with snails, freshwater limpets are also placed into the class Gastropoda (Brown 2001). Seven families of gastropods with 8 genera were collected from Lady Bird Lake. *Melanoides turberculatus* is a non-native snail, and it is more tolerant of pollution and still water than native snails that they are similar to (Pleuroceridae). *M. tuberculatus* is one of three species know to be in North America. They are popular aquaria snails and have also been introduced as biological controls for schistosomiasis "swimmers itch", which is transmitted via a fluke that resides in *Biomphalaria* spp. They out-compete the later, and are not viable hosts for the schistosomiasis fluke. They can however, be hosts to other parasites such as the human lung fluke. *Melanoides tuberculatus* can become tremendously abundant and compete with native snails (Perez *et al.* 2004).

North American freshwater Bivalvia are the most diverse in the world, and consist of about 308 native species as well as 7 introduced taxa. Bivalves have a hinged shell that is composed of two parts. They are filter feeders and are often seen as very pollution sensitive species. Freshwater mussels are dorso-ventrally expanded, and this allows them to burrow into fine sediments (McMahon and Bogan 2001). Lady Bird Lake had two families of bivalves commonly collected: Corbiculidae and Pisidiidae. *Corbicula fluminea*, also known as the Asian Clam, was first documented in Texas by Metcalf in 1966 (Howells *et al.* 1996). This clam can tolerate a wide variety of habitats such as fine silts, mud, sand, gravel, cobble and bedrock; it can also live in lentic or lotic water systems; turbid to clear water; and water depths of only a few mm to at least 18 m deep (Diaz 1974). Even though the introduction of the Asian Clam is considered a negative one, they have been used as filtration agents for wastewater purification. They are also consumed by many native fishes such as blue catfish (*Ictalurus furcatus)*, channel catfish (*I. punctatus*), common carp (*Cyprinus carpio*), freshwater drum (*Aplodinotus grunniens*), redear sunfish (*Lepomis microlophus*) and Pacific sturgeon (*Acipenser* spp.). Fingernail clams and

Peaclams are generally small clams usually under 25mm in length. They occur in a variety of habitats, substrate types, depths and water conditions. They are of no economic importance but serve as a food source for fishes and other animals (Howells *et al.* 1996).

Annelids, segmented worms, collected from Lady Bird Lake represent two subclasses: Oligochaeta and Hirudinea. Oligochaetes are commonly referred to as worms and can have both terrestrial and aquatic forms. One of the most notorious aquatic worms is the Tubificidae or sludge worms. These worms can form dense colonies and can withstand heavily polluted waters. Oligochaetes are found in every type of freshwater and estuarine habitat, along with being found in organic mud. Some worms can be found in groundwater, oligotrophic lakes and streams, and can serve as commensals or sybionts on crawfish, mollusks, and even tree frogs. Some North American oligochaetes feed upon other worms and some small invertebrates (Brinkhurst and Gelder 2001).

Hirudinea are commonly known as leeches, and they serve as an important component of the benthic community of lakes, ponds, streams and rivers. Seventy-three species are found in North America, with a majority of them feeding upon chironomids, oligochaetes, amphipods, and mollusks. Leeches are best known for their sangivorous feeding (blood feeding). This is generally considered a temporary stage, but during this stage they are known to become ectoparasites of fish, turtles, amphibians, crocodilians, water birds, and occasionally humans. Hirudineans are able to inhabit waters with low salt (NaCl) concentrations as wells as salt water which exceeds that found in the ocean. Some can withstand systems that have no oxygen present, while some can be found in supersaturated oxygen waters. In smaller aquatic systems leeches are considered to be among the top predators, while in larger aquatic systems they become an important part of fish diets, and are often commercially grown as fish bait. Along with their importance in ecological settings, some leeches are being investigated for pharmacological properties due to the anticoagulant properties of their salivary secretions (Davies and Govedich 2001).

Phylum Platyhelminthes was represented by one species, *Dugesia tigrina*. Platyhelminthes are commonly referred to as flatworms or tubellarians. Flatworms are common and sometimes numerous in freshwaters. Tubellarians have only one opening to their digestive tract, and therefore lack an anus. Most freshwater tubellarians range in size from 1mm to several centimeters in length. Freshwater tubellarians are mobile and live in a variety of habitats (Kolasa 2001).

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